

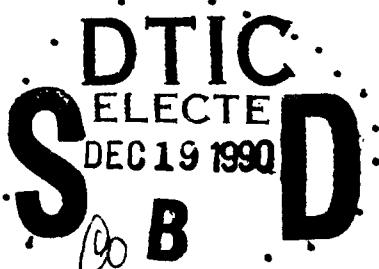
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Executive Thinking and Decision Skills: A Characterization and Implications for Training

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FOREWORD

This project is part of an ongoing research program on executive leadership development conducted by the U.S. Army Research Institute for the Behavioral and Social Sciences. This program focuses on identifying the thinking and decision skills that determine executive performance and developing methods to assess and develop these skills. Past research, most notably the work of Elliott Jaques and his colleagues, has identified a set of skills that characterize executive-level performance.

This research develops a theory of the cognitive structures that support executive-level thinking and decision skills. The report reviews earlier work, including work sponsored under this research program, on the skills possessed by executives. Findings from an observational study of graduating National Defense University students documents how their decisionmaking processes differ from those of executives. The findings are explained in terms of a theory of the cognitive architecture of executives and how this architecture supports their unique abilities.

Results of this preliminary phase of research suggest that the theoretical approach developed under this project forms the basis of a promising approach to executive development. The report recommends a training approach based on the theoretical findings outlined here. While work remains to develop further and implement the theory presented here, the recommendations presented in this report show considerable promise for improving the Army's executive development process.

EDGAR M. JOHNSON
Technical Director



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EXECUTIVE THINKING AND DECISION SKILLS: A CHARACTERIZATION AND IMPLICATIONS FOR TRAINING

EXECUTIVE SUMMARY

Research Requirement:

A successful Army requires top-notch leaders. This report describes a research project designed to support the Army Research Institute's program of research in executive-level leader development. This ARI program is directed at identifying the thinking and decisionmaking skills characteristic of executives and formulating methods of assessing and developing these skills.

The research reported here supports this overall ARI objective. The goal was to develop a theory of the cognitive structures underlying the knowledge, skills, and cognitive strategies exhibited by successful executives. This report represents a preliminary attempt at documenting the cognitive structures required for successful executive performance and how these differ from the cognitive structures present at lower levels. Our findings are based on a review of literature describing the decision-making strategies characteristic of executives, and a comparison of these findings with an observational study of graduating students at the National Defense University. Hypotheses regarding the development of executive performance are presented and preliminary recommendations for leader development programs are outlined.

Procedure:

The first stage in our research was to review the literature to examine what is known about executive skills and to establish a theoretical framework within which the rest of the research was to be conducted. Literature on the characteristics of executives and the environment within which they operate was reviewed. This was contrasted with literature focusing on the behavior of experts, who typically operate at lower than executive level. Theories of the cognitive structures required for expert reasoning and problem solving were reviewed. The need for cognitive modeling of executive knowledge and skill requirements was identified.

The next stage in our research was to observe the behavior of graduating students at the National Defense University (NDU) in the Crisis Decision Exercise (CDE). This exercise culminates

their tour at NDU and gives them the opportunity to exercise the skills they have been developing during their study. The students are currently at the Lieutenant Colonel or Colonel rank. The purpose of the observation was to characterize their approach to the kind of problem that would be faced by an individual at the executive level, to examine the extent to which executive-level behaviors are developing, and to identify behaviors and skills that require more attention.

The third step was to synthesize the findings of the literature review and the exercise observation into a theory of the cognitive structures required for successful executive-level experience and to identify similarities and differences between these structures and those possessed by individuals at the Lieutenant Colonel and Colonel level.

The final step in our research plan was to develop recommendations for interventions that will foster the development of executive-level cognitive structures as officers move through the ranks. These include both suggestions for emphasis within the NDU program and suggestions for on-job development measures that could enhance the development of higher ranking officers.

Findings:

Graduating NDU students differ from executives in three key areas related to planning and decisionmaking strategy. First, the students planned reactively, generating tactical-level plans in response to events. These plans were related to global goals after the fact, if at all. By contrast, executives plan proactively, explicitly planning for their global objectives as they respond to events. Second, the students did little contingency analysis. Plans were evaluated by projecting a single most likely scenario and evaluating whether the outcome was satisfactory. By contrast, executives look for ways their plans could fail and generate contingency plans to respond to possible failures. Third, students considered mostly first-order consequences of their plans, and evaluated plans mostly from their own perspective. By contrast, executives project higher-order consequences and adopt the perspective of other parties to analyze their likely response.

Probably because of their local, reactive, first-order approach to planning, the students planned over a much shorter time horizon than do executives. They showed little meta-cognitive awareness of their own planning strategies.

We hypothesize that these differences between NDU students and executives stem from three sources. First, the CDE itself induces artificialities in student behavior to cope with time

constraints and perceived expectations. Second, students have less knowledge than executives--their causal map of the CDE decision domain is much less well developed than would be an executive's. Third, their knowledge is not organized in a way that facilitates global, top-down planning. This latter problem is, we believe, the more basic. A good organizational structure facilitates building the deeper causal knowledge that will be required as students move to the executive level. We suggest that executives have developed an "executive layer" in their cognitive architecture that organizes and manages lower-level cognitive structures. The executive layer in the mind thus serves a purpose similar to the executive level in an organization. People can function well as executives only to the extent that they have a properly functioning executive layer in their cognitive architecture.

Utilization of Findings:

Currently, executive layer cognitive structures are developed unsystematically. Only a few individuals develop them sufficiently well to become effective executives in spite of training programs such as those at NDU. This underscores the need to develop executive abilities in greater numbers of people to the extent training methods can be developed to do so. The literature on metacognitive instruction suggests that these structures can be developed to a greater degree in all individuals. This suggests both that the pool of potential executives might be expanded and that those who become executives might be trained to a higher degree of proficiency.

We recommend that instructional interventions be developed with the explicit intent of developing the executive layer in students' cognitive architectures. We recommend programs both at the school level (e.g., NDU) and beyond. Interventions beyond the school years should be aimed at strengthening existing mentoring and coaching relationships. Short courses directed both at aspiring executives and at their mentors and coaches should be developed.

We recommend that explicit metacognitive instruction be carried out within the context of specific decisionmaking and planning problems. Abstract instruction on the above meta-structures will at best develop a declarative knowledge of the structures and their relevance. Abstract integrative structures like the target structures develop only after a great deal of experience applying them to concrete situations. But this development can be facilitated by explicit instruction on the strategies within the context of the specific application on which they are being practiced, and by pointing out the commonalities of approach in different contexts to which they have been applied.

Our approach to instruction has three components: an overview that sets the problem solving context and relates it to other similar contexts, top-down instruction in which students tailor global, high-level plans to specific problem situations, and bottom-up instructions in which students start with the problem situation, evaluate it in terms of higher-level objectives, and generate a plan. Top-down instruction forms links from high-level integrative structures to situational knowledge; bottom-up instruction forms links from situational knowledge to global goals and planning strategies.

The theory developed under this project is still in its formative stages. We recommend two major directions for further research. The first is validation of the findings and recommendations arising out of the present project. We recommend developing an instrument for measuring the existence of executive-layer cognitive structures. We also recommend implementing instructional interventions such as those outlined in this report and evaluating their effectiveness. The second research direction is further development of the theory itself. This involves further theoretical work on the organizational structure of the executive layer of the cognitive architecture, as well as work on the mechanisms by which the executive layer develops. This research will eventually lead to more effective instructional interventions.

**EXECUTIVE THINKING AND DECISION SKILLS: A CHARACTERIZATION
AND IMPLICATIONS FOR TRAINING**

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EXECUTIVE THINKING AND DECISION SKILLS:
A CHARACTERIZATION AND IMPLICATIONS FOR TRAINING

1.0 INTRODUCTION

Although bureaucracy is often decried as a modern evil, it can be argued that its invention has made possible the development of modern civilization (c.f., Drucker, 1986). No single individual can possibly have the knowledge or the resources required to build an M-1 tank or an Advanced Tactical Fighter. The contributions of thousands of individuals are required--from the design engineer to the assembly line worker to the payroll clerk. Each bit is insufficient in itself, but together they produce a technological marvel. The skills and knowledge of each participant would go to waste if there were no organizational structure to focus their efforts in a consonant direction. In fact, modern technology itself would not be possible if not for bureaucratic institutions that focus large numbers of people on pushing forward the frontiers of scientific and technical knowledge.

Among the largest and most important of modern organizations are the military establishments of the large industrial nations. Managing an organization as large and complex as the U.S. Army requires leaders of the highest caliber. The Army has long recognized this need, and has been at the forefront of research in leader development.

Leadership skills are required at all levels of the Army hierarchy. Each level requires different kinds of skills (cf., Jacobs and Jaques, *in preparation*). Lower levels (squad, company, battalion) are characterized by direct leadership. At these levels, leaders are concerned with the accomplishment of specific tasks, and interact directly with the subordinates responsible for completing the tasks. The next higher levels (brigade and division) are characterized by organizational leadership. At these levels, leaders coordinate and facilitate the accomplishment of a broader range of specific tasks, and interact only indirectly with those responsible for carrying out the tasks. Finally, the highest levels (corps, theater, and MACOM) are characterized by executive leadership. At the executive level, leaders are concerned with establishing and communicating a broad vision, setting a context within which meaning and direction are given to activities at lower levels.

This report is concerned with leadership at the executive level. Leaders at this level in the Army are three- and four-star generals. These leaders exhibit behaviors and thought processes that are unique. The research reported here responds to the Army's need to foster the development of these unique executive skills. The ultimate goal of the Army Research

Institute's program of research in executive development is to identify the skill set possessed by executives, build a theory of how these skills are developed as individuals move through the ranks to the executive level, and use the theory to derive recommendations for school training and post-school interventions to facilitate the process of executive development.

A first step toward this goal is to characterize the thinking, planning, and decision making processes of executives and how they differ from non-executives. This establishes a set of target behaviors toward which training can be directed. A second step is to develop a theoretical framework within which the determinants of these behaviors and their development can be understood. The aim is to understand the cognitive structures characteristic of executives, and how these relate to and develop from the cognitive structures characteristic of leaders at lower levels. Such a theoretical framework allows training and leadership development efforts to be targeted toward behaviors and skills that are precursors to those that will be required of future executives. The final step is to develop specific recommendations for the training of executives based on the results of steps one and two.

Executive skills develop over a long period of time, much of it of necessity after formal schooling has ended. There are two major implications of this fact with respect to strategies for enhancing executive development. First, to the extent possible, school instruction should explicitly attempt to instill in students the foundations on which they can later develop executive reasoning strategies. Second, post-school assignments should be designed to provide opportunities for building the skills that will be required at higher levels. This could include facilitation of mentoring, "work ahead" assignments, and short courses focusing on intensive development of specific targeted skills or strategies. The effectiveness of interventions will be enhanced to the extent that they are based on a good theory of how executive decision making processes develop, and on the cognitive substrate necessary for their development.

The remainder of this report is organized as follows. Section 2 reviews previous research related to executive skills and their development, and establishes the basic theoretical framework within which the research was conducted. Section 3 describes current Army practice with respect to executive development. Section 4 describes an observational study performed under this effort. Decision making behavior of organizational-leadership level Army officers (graduating students at the National Defense University at the Lt. Colonel and Colonel levels) was observed and compared to executive behavior. Section 5 synthesizes our observations with previous research to develop a theory of executive decision skills. Section 6 lays out recommendations, based on these research

findings, for fostering the development of executive skills in the Army. Finally, Section 7 outlines potentially fruitful research directions in the area of executive development.

2.0 WHAT MAKES AN EXECUTIVE: PREVIOUS RESEARCH

2.1 Overview

Executives exhibit behavior and possess skills that are qualitatively different from people at lower levels of the executive hierarchy. Research has shown (cf., Jaques et al., 1986) that these characteristics are common to both military and corporate executives. They therefore appear to arise in response to the demands of managing a large-scale, complex organization, whatever its type or mission. Despite these unique characteristics of executives, as human beings they share a common cognitive architecture with the rest of us. Moreover, they did not always possess these unique executive characteristics (although it has been argued that those who develop into executives have always possessed cognitive strategies and character traits indicative of executive potential).

If we are to find better ways of fostering the development of executive skills in those with executive potential, we need to understand the unique skills possessed by executives, the cognitive structures that make these skills possible, and the developmental sequence by which these structures develop.

This section contains a selective review of literature on executive development and those aspects of the general cognitive science literature relevant to a theory of cognitive structures underlying decision making performance. A basic theoretical framework is outlined that guided the data collection methodology for the study described in Section 4 of this report. The theory provided a framework within which the data was interpreted, and the data provided a basis for verifying, modifying, and extending the theory.

2.2 Characteristics of Successful Executives

A coherent picture of the successful executive emerges from synthesizing the work of different authors who have studied executives. The work of Elliott Jaques has provided a framework for understanding complex organizations, the types of work required at each level of the organizational hierarchy, and the skills exhibited by individuals with different responsibilities within an organization. According to Jaques' theory, perhaps the most important functions of the executive's role are (1) to provide a coherent vision or sense of purpose to guide the activities of those within the organization, and (2) to tap resources, often outside the organization, that enable the organization to carry out its purpose (Jacobs and Jaques, in preparation).

The executive obtains the cooperation of both subordinates

and resource holders by molding perceptions and shaping consensus about goals and proposed actions. Relative to those at lower levels of the hierarchy, then, the executive is concerned less with concrete technical issues and more with goals and broad, high-level plans for achieving the goals. Unlike mid-level, managers, however, executive goals tend to be more abstract, visionary and less tangible. An executive may set a policy goal of "maintaining market leadership," while mid-level managers may be tasked with translating this vision into concrete sub-goals (e.g., introduce product A into the market). The executive leaves the detailed implementation of plans to others, but must have a general sense of the feasibility of plan implementation. The executive has a long time horizon, generally in excess of ten years. The scope of his concern goes beyond the organization, and often to the international arena. His focus is not on a single system, but on the interrelationships among different systems. (For example, the three- or four-star general must balance not only Army concerns, but joint service, political, international, and economic concerns as well.)

The progression from lower to higher organizational levels is accompanied by several shifts in emphasis: (1) from technical to abstract analytic to abstract integrative thinking skills; (2) from shorter to longer time horizons; (3) from direct to less direct forms of control; (4) from system component to system to multi-system perspective (Jacobs and Jaques, *in preparation*). This progression must be accompanied by an increase in the complexity of the executive's causal map, or mental model of the cause and effect relationships governing the systems with which he deals. This causal map must be sufficiently complex to enable the executive to perceive causes and effects over long time horizons, spanning different organizational entities, and including different types of causal factors. The executive's causal map must encompass motivations and behaviors of individuals in different organizations and organizational subunits, thus enabling negotiation and consensus building across different organizations. Finally, the executive's causal map must enable him to make sense of uncertainties and ambiguities.

Ingber (1984) has identified a number of characteristics of good executives. First, good executives think broadly--they think of problems along a number of dimensions. Second, they are able to consider many problems simultaneously, finding links between different problems. Third, good executives are willing to act before all the facts are in. They use their actions to "test the waters", gaining information about the efficacy of different strategies. Fourth, they exhibit empathy toward their colleagues and subordinates, finding the reason for and correcting problems rather than blaming the perpetrator. Fifth, they have a well-developed intuition, an ability to pick out pattern amid seemingly chaotic data. Sixth, good executives can tolerate surprise and ambiguity. Finally, when good executives

plan they generate multiple contingencies. These characteristics are consistent with Jaques' theory. In particular, a well-developed causal map is necessary for broad thinking, intuition, tolerance of uncertainty, and ability to take action before the facts are in. Ingber's finding of empathetic behavior is consistent with the executive's role as motivator and consensus shaper.

Wagner (1987) discusses important determinants of "practical" (as opposed to academic) intelligence as exhibited by executives. First, successful executives are able to bring together both a local and a global perspective on problems. That is, they are able to focus on completing the immediate task at hand, while at the same time being aware of how that task relates to the other tasks and the overall organizational context. Second, executives possess practical knowledge about how to manage themselves, other people, and tasks. Third, executives can balance ideal versus actual thinking. That is, they are not bound by conventional wisdom about what is possible, but neither are they pie-in-the-sky dreamers. The best executives set high but achievable aspirations for themselves and others. Again, these findings mesh well with the research described above.

These unique characteristics of executive behavior appear to be valid predictively as well as descriptively. Wagner and Sternberg (1985) have developed a questionnaire that predicts the position of executives in the corporate hierarchy. Stamp (1988) developed an intensive individual interview instrument, called the Career Path Appreciation (CPA), that was based on Jaques' theory of organizational structure. The CPA successfully predicts individuals' organizational position up to thirteen years from the time it is administered, suggesting that the determinants of executive behavior begin manifesting themselves long before the individual actually reaches the executive level. Jaques (1976) has fit a set of curves to the development of an individual's time span of discretion, or the maximum time span over which the individual can plan and successfully carry out a project without monitoring. Given an individual's age and a current measure of time span, the curves predict time span development in later years. A key tenet of Jaques' theory is that time span correlates with the organizational stratum in which the individual is capable of operating. Thus, time span measurement is also a reliable predictor of executive potential (Jaques, et al., 1986).

The success of prediction instruments suggests that individuals with executive potential could be identified early and groomed for their future positions. It also suggests that it might be possible to increase the potential pool of future executives by focusing training on the skills and behaviors that are precursors of executive performance.

2.3 Insights from the Theory of Expert Knowledge Representations

2.3.1 Relevance of the expert knowledge literature. The advent of artificial intelligence and computer models of symbol manipulation has opened a new door in the field of cognitive psychology. Implementing a theory of human cognitive processing in a computer demands a new level of precision and rigor in psychological models. Moreover, theories of human knowledge representation and reasoning can now be tested by implementing them on a computer and comparing computer and human performance. Recent years have seen great strides in theories of human cognitive processing.

Much of the work in computer representations of human knowledge has been directed at experts (largely because of the demands of expert systems applications). The kinds of experts studied by cognitive psychologists tend to be subject matter experts in technical domains. Thus, at first glance it might seem that this line of research has little to offer researchers studying the unique characteristics of executives.

There are several reasons why we believe this first impression to be wrong. First, to the extent that there are fundamental properties of human knowledge organization and structure, these properties will generalize to executives as well as experts. Much has been gained from studies comparing novices and experts, and we expect that comparing technical experts to executives will yield new insights about how cognitive structures develop. Second, executives are recruited from the ranks of experts, and executive knowledge structures must be built on a foundation of expert knowledge structures. Our research seeks to identify what components of experts' knowledge form a good foundation for the development of executive skills, and to identify potentially counterproductive knowledge structures and reasoning strategies that may inhibit growth to the executive level. Ultimately, this line of research could be a powerful tool for identifying individuals with executive potential, and perhaps for increasing the number of individuals who exhibit such potential. Third, executives themselves can be viewed as experts, albeit experts of a unique kind. Executives are experts not at some technical domain, but at complex organizational management problems of the kind discussed in Section 2.1 above. Thus, a nonnegligible amount of direct transfer from the expert knowledge literature can reasonably be expected.

The experimental literature points to the following differences between experts and novices. First, expert knowledge tends to be highly integrated and tightly organized. Hence, experts alternate between high-level and low-level analysis as needed for problem solving. This finding is reminiscent of the finding noted above that executives think both globally and locally. Second, experts have rich high-level abstract knowledge

(Larkin, 1981), which they use to select problem-appropriate general principles and specific solution plans. Third, expert knowledge is highly differentiated and experts can recognize a vast number of different problem-instantiated patterns (Chase and Simon, 1973). Abstract knowledge and pattern recognition are important characteristics of the well-developed intuition referred to above. Finally, experts tend to have detailed causal models that allow them to diagnose problems and understand how outcomes are affected by intended courses of action (Leddo and Cohen, 1987; Leddo et al., 1987). This latter characteristic relates to a number of the abilities cited above, including the ability to act before all the information is in, to plan for multiple contingencies, and to set ambitious but realizable goals. Note the similarity of this finding to Jaques' theory, in which executives have complex and rich causal maps of the organizations in which they are operating.

2.3.2 A theory of expert knowledge representation. When asked what makes an expert, most people would say that experts "know a lot" about their domain of expertise. But as cognitive scientists and artificial intelligence researchers have attempted to build computational models of cognition, it is becoming increasingly clear that amount of knowledge is only a secondary characteristic of expertise (as well as of everyday, garden variety intelligence).

Imagine having a great deal of information about the income and spending habits of Americans, in the form of a large warehouse stacked full of the IRS return of every American and the sales receipt from every purchase made by every American. The raw information in this warehouse would be a gold mine for the marketing division of any consumer product firm. But in this form it is of absolutely no use, because it is totally unorganized. There is no way for the right information to be accessed at the right time.

Now imagine the same information organized as a large database. A market researcher could ask the database system questions such as: "Give me names and addresses of households in the Chicago metropolitan area with incomes of over \$35,000 per year and who go to at least two football games per season." The raw information has now been organized in a way that is useful to the market researcher. She can use it to make inferences about the size of the potential market for a new product, to identify groups of people as targets for direct-mail advertising, or to predict which areas of the country are likely to be most promising as new markets for a product.

This warehouse analogy illustrates an important point for a theory of knowledge representation. Knowledge, to be of value, must be organized around the goals, or purposes, to which use of the knowledge is to be directed. The organizational scheme must

be such that the right kind of knowledge can be accessed at the right time to allow the individual's purpose to be achieved. Hence, any planning or causal knowledge people possess will typically focus on the causal relationships and actions that affect these goals. For example, a corporate executive will focus on the economic factors as they affect how consumers buy his product, rather than attempting to understand every nuance of economic theory. Given that the amount of knowledge available is prohibitively great, goals serve as a valuable means for focusing experts and executives on manageable subsets of that knowledge.

Experts possess different kinds of knowledge: goal and planning knowledge, knowledge of situation specific procedures, knowledge of patterns, content knowledge of objects, causal models of how events are produced and high-level, integrative knowledge (cf, Leddo and Cohen, 1987; Leddo et al., 1987). A theory of knowledge representation and organization needs to be able to account for all these knowledge types and provide for their access when they are needed.

One of the earliest knowledge representation frameworks, and still a very popular one, is the production rule (cf. Newell and Simon, 1972). Production rules are expressed as "IF [antecedent], THEN [consequent]", where antecedents are situational conditions which determine when procedures are to be executed and consequents are the procedures executed under those conditions. Production rules are useful both in carrying out actions/plans (e.g., "If this is the situation, then do these actions") and also in generating inferences (e.g., "If the following data are observed, then infer that this is the situation").

Production rules have been widely applied in expert systems, often very successfully. A number of popular expert system shells allow rapid encoding of a set of rules about a domain into an expert system that applies the rules to solve problems in the domain. These shells can be used even by people with little background in artificial intelligence.

Early expert systems and shells paid little attention to the control problem: how the system decided which rule to apply next. Most systems used simple forward chaining (apply the next rule whose antecedent is satisfied) or backward chaining (given a goal state, search for a rule whose consequent is the goal and set its antecedent as a new goal). Like our warehouse, the database of rules was an unstructured collection. The rule interpreter had to search through the entire collection until it found a rule that applied.

This scheme works for small and uncomplicated problems, but breaks down rapidly as the database of rules gets larger. Researchers began to search for ways of organizing rules into

higher order structures. This search has involved a great deal of cross-fertilization between artificial intelligence and cognitive psychology. AI researchers look to humans as inspiration for models of intelligent behavior; cognitive psychologists test their theories by implementing them on computers and comparing the results with experimental findings.

As noted above, a major application of production rules is in problems of planning and plan execution. One way of organizing rules for planning problems is as scripts (Schank and Abelson, 1977). A script is a sequence of actions organized around a goal. We can think of a script as a series of production rules that are executed one after another. It is hypothesized that with practice, the individual "compiles" a package of rules with the goal that their execution achieves. Invoking and executing a prepackaged script is much faster than searching a vast rule base for each rule in the collection.

Scripts are only one example of the kinds of planning structures, or schemas, that have been proposed in the AI and cognitive science literature. A planning schema associates a goal with a plan for its achievement. Scripts have very simple plans--fixed sequences of low-level actions. Schank and Abelson later generalized the script into a Memory Organization Packet, or MOP. Like a script, a MOP prescribes a sequence of actions. But unlike a script, the actions in a MOP are themselves complex structures. Thus, a plan for an attack might involve preparing forces for attack, sending out a covering force, initiating the main attack, and then bringing in the reserves. Each of these actions is itself a plan and is represented by a planning structure.

MOPs and scripts execute actions in a fixed temporal sequence. Other kinds of planning schemas allow for contingencies (if a goal succeeds, execute one plan; if it fails, execute another), concurrent goals pursued in parallel, and other kinds of more complex sequencing dependencies.

In general, a planning structure organizes a goal, a plan for achieving the goal, and situational conditions for when the plan is invoked. The plan itself is an organized collection of actions and/or other planning structures. A planning structure organizes and facilitates access to a large collection of lower level knowledge. To invoke the plan, the system needs to perform inference--to decide whether the situational conditions for invoking the plan are satisfied. As for planning knowledge, situational knowledge must be organized to facilitate access--in this case, the knowledge required for drawing inferences.

Examples of frameworks for organizing situational knowledge are object frames and semantic networks. Knowledge about data-patterns and how objects are organized together can be

represented by object frames (cf. Anderson, 1980; Minsky, 1975). Similar to scripts, frames are expectancy-driven organizers of knowledge. Scripts focus more on goal and plan-related knowledge while object frames organize collections of objects (these objects may themselves be object frames). Frames can also be distinguished from semantic nets (cf. Quillian, 1966). Semantic nets tend to organize information about individual concepts and relationships between them; object frames encode how a collection of interrelated objects is organized.

If the world were well bounded and the individual never had to learn anything new, the kinds of knowledge described above would suffice. But sometimes things go wrong: the individual makes an inference that proves false, or executes a plan that fails. Now she must recover. Recovery means deciding why things went wrong, and then patching up the knowledge base to prevent the failure from reoccurring (e.g., making rule conditions more specific; developing more refined concepts; adding contingencies to plans). Causal knowledge about why plans work is essential to adapting to unexpected events and learning.

Causal and analogical reasoning can be captured by mental models (cf. DeKleer and Brown, 1981; Johnson-Laird, 1983; Leddo, Cardie and Abelson, 1987; Leddo and Cohen, 1987; Leddo et al., 1987). In our framework, mental models are viewed as representations of the causal mechanisms which underlie events. Mental models include information regarding how forces and objects interact to produce outcomes. As a result, mental models can be used to predict events or explain why they occurred. Mental models can refer to physical events such as how fast a tank column can move across a highway, cognitive events such as what a general's model of the battlefield is (often military success hinges on the ability of a commander to understand his counterpart's mental model of the battlefield), or more abstract events such as the principles of war.

We have discussed five different representation frameworks (planning schemas, object frames, semantic nets, production rules and mental models) for representing expert knowledge. As discussed earlier, work by the project team has shown that each of these frameworks is most natural for representing a different aspect of experts' knowledge. It is important, then, to integrate these frameworks into a general framework of knowledge representation. We have developed a framework, called the Integrated Knowledge Structures (INKS) model, that integrates these five representation frameworks (Leddo, Cardie and Abelson, 1987; Leddo and Cohen, 1987; Leddo et al., 1987). Planning schemas serve as the general organizer of knowledge, linking plans and goals. Production rules give situation specific procedures to be executed given conditions that arise during execution of a plan. Frames organize collections of objects used to execute plans while semantic nets organize features for the

individual objects within a frame. Mental models provide the causal rationale for why procedures are executed and how they achieve objectives. They can also be used to generate predictions of the outcomes of plans selected in a particular context (i.e., they integrate situational knowledge with goal and planning knowledge).

For example, a representation for conducting an offensive operation using our integrated representation framework might start with a MOP depicting the general goals of the mission and plans for achieving those goals. These plans would include general procedures such as preparing for the battle, how to deploy forces, movement to contact, etc. Within these plans would be production rules for how to accomplish these steps. The representation would also include frames that are referenced by the script and associated production rules. For example, if a reference is made to "doctrinal disposition of Soviet defensive units", a frame representing that information is activated, and would include such things as frontages, placement of artillery, etc. Similarly, semantic nets are linked to the concepts contained in the frames (e.g., artillery) as well as to concepts referred to elsewhere but not contained within a particular frame. Finally, mental models may be linked to production rules or general plans and procedures to give underlying rationales or generate predictions of plan outcomes. For example, a mental model regarding the "principle of mass" might contain relationships between the numbers of forces and the outcomes of the battles. These relationships may contain quantitative formulae (as are often used in force ratio analyses) that are expressed in production rules (e.g., If the ratio of attackers to defenders is six to one, then the attack has at least a 50% probability of success).

Our integrated knowledge representation has been used to develop strategies for eliciting knowledge from experts, to build models of expert knowledge based on the elicitation, and to analyze the structural differences in knowledge of people at different levels of expertise (Leddo and Cohen, 1987; Leddo et al., 1987). This framework also formed the theoretical basis for an intelligent training system (Leddo, Sak and Laskey, 1989) for Follow-on Forces Attack. In addition, the scheme has been implemented both in a planning and an understanding AI system (Leddo, Cardie, and Abelson, 1987). This experience suggests that our framework holds promise for developing a training methodology designed to impart knowledge structures required for executive level performance.

Figure 1 shows a template of the INKS framework with sample inter-connections between the individual knowledge structures.

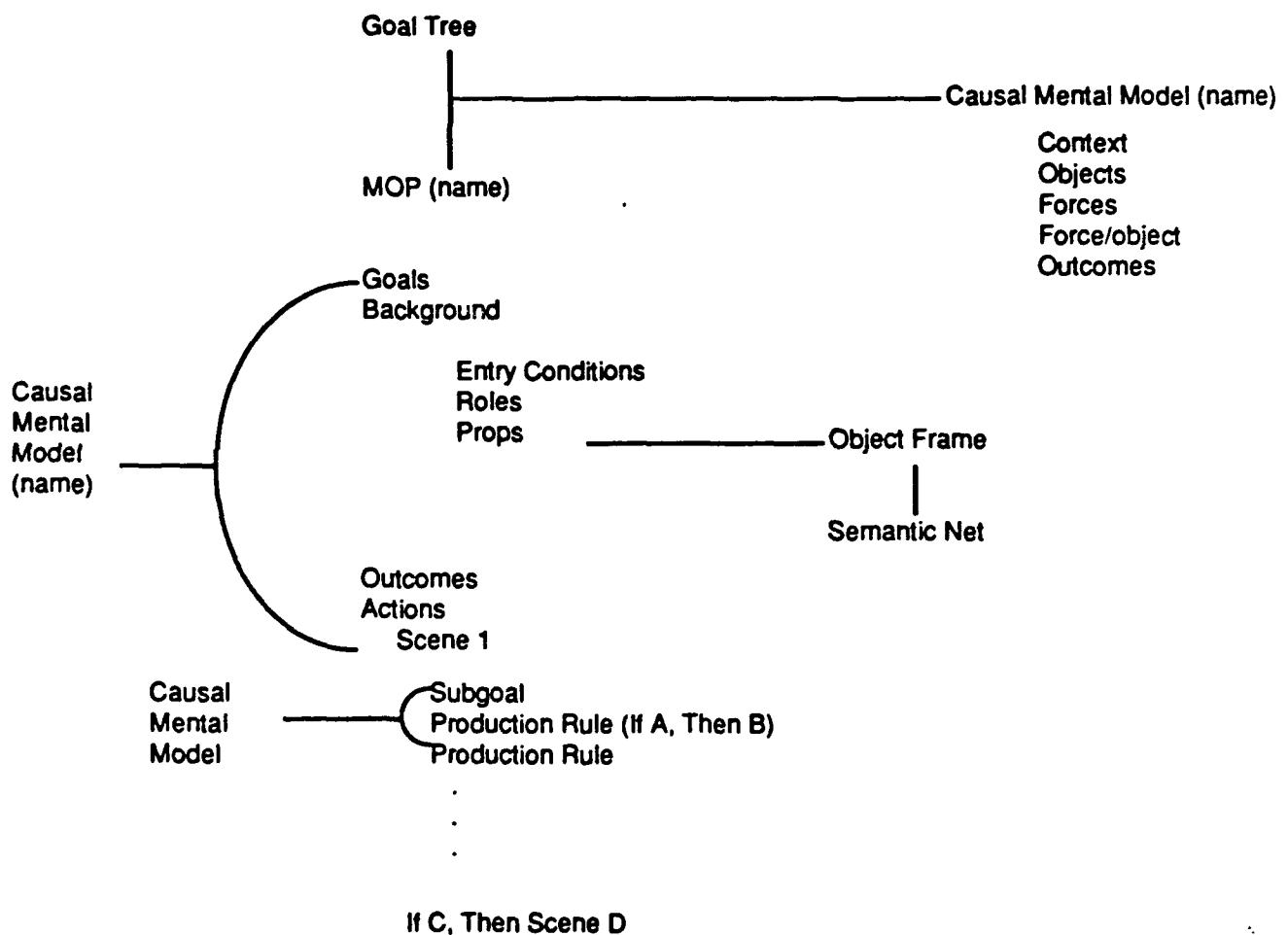


Figure 1. INKS Framework (with sample knowledge links).

2.3.3 Experts and executives: The contrast. The goal of this project is to develop hypotheses about how the knowledge of executives is organized, and how the organization of their knowledge differs from that of non-executives. The knowledge structures of the INKS model serve as a starting point for our investigation. We have pointed out the relevance of theories of expert knowledge to the study of executive behavior and thinking skills. But there are systematic differences between technical experts and executives, and these need to be accounted for in a theory of how executive knowledge is structured. We attempt to analyze how knowledge is organized in executives, and what it is about this organizational structure that enables the power exhibited in executive planning and problem solving strategies.

Table 1 summarizes the contrast between subject-matter experts and executives, who we might call organizational process experts.

As noted above, successful executives adopt a broad scope when thinking about problems. By contrast, subject matter experts tend to focus more narrowly on the area of their own expertise. For example, in a military crisis a G-2 is likely to focus on enemy strengths and capabilities, while a theater commander is likely to focus on the political as well as military implications of responding militarily versus taking non-military action. This division of labor is entirely functional in large organizations. The executive delegates in-depth analysis on single issues downward to subject matter experts, and focuses on integrating their top-level conclusions to arrive at an overall picture of the situation.

The executive's time horizon is generally longer than that of the expert. Studies of expert problem solving suggest that experts perform best on problems that are short range in nature, and usually with uncertainties that can be controlled or neglected. Such problems are often found at organizational mid-levels. The executive is forced to deal with long-range issues facing the organization, and with a changing and unpredictable environment. The executive must manage this complexity to create adaptive courses of action to respond to a highly uncertain future.

Related to scope and time horizon is the perspective taken by experts versus executives. Experts tend to adopt a single perspective, that of their own area of expertise. For example, an intelligence officer's job is explicitly to adopt the perspective of the enemy commander. Executives, on the other hand, integrate the many perspectives taken by different advisors. Experts must consider the perspective not only of different organizational subunits, but of extra-organizational entities as well. A characteristic of the good executive is the ability to seek out diverse and often conflicting viewpoints from

individuals whose perspectives are important to take into account. A danger to which executives can succumb is to be shielded by a close coterie of advisors from viewpoints not shared by the "inner circle."

While experts often participate in group processes, and must learn group interaction skills, their role is usually to present particular in-depth technical analyses or to gain support for their own group's perspective. While experts often lead groups, the members of such groups typically share a common set of technical skills and goals (although individuals may have their own agendas). For example, in the division level all source production section, the members are all intelligence experts working together to map out a picture of the enemy situation. The leader of this group is also a technical expert, who is less of a specialist (e.g., signal intelligence), but rather has general technical expertise in each of the specialties that comprise the group expertise. Such experts who lead technical groups can be likened to surgeons who direct anesthesiologists, radiologists, and nurses during surgery.

Executives manage the interaction of the different technical groups. In order to accomplish this, the executive must have extensive non-technical skill. This includes balancing the individual group goals, making sure all viewpoints are heard, keeping conflicts that arise from getting out of control, and building consensus on a course of action. To do this effectively, the executive must understand the role and unique personality characteristics of the group members, especially their reward and motivation structures. He/she must be a master at building solutions that satisfy the needs of all affected constituencies, and at making all group members feel that their viewpoint has been incorporated into the final consensus. Finally, he/she must be able to motivate group members to "own" the group solution, so that they implement it enthusiastically.

Whereas the expert's role is usually to provide input to the group on his own area of expertise, the executive must absorb and integrate inputs from a number of experts. He/she must combine these with his knowledge of how the organization functions to develop a course of action that is both technically and organizationally workable.

All these contrasts point to another contrast. The expert's primary focus is on content. He analyzes courses of action from a technical standpoint to see whether they are workable from the point of view of his/her area of expertise, and to identify potential trouble spots. The executive is process oriented. His/her primary focus is on how to develop a solution, within certain technical constraints, that is organizationally workable, and to develop a plan to mobilize internal and external resources toward accomplishing the solution. He/she has delegated process

Table 1

Contrast Between Executives and Subject Matter Experts

<u>EXECUTIVE</u>	<u>EXPERT</u>
Adopts broad scope	Performs in-depth analysis with narrow scope
Adopts multiple perspectives	Adopts single perspective
Considers long-range consequences	Performs best on short-range problems
Manages group interactions	Participates in group
Integrates multiple inputs	Provides input to integrator
Focuses on process	Focuses on content

analysis to experts. They are responsible for analyzing courses of action for technical feasibility and providing him/her with input on the kinds of solutions that meet technical constraints.

These differences between executives and technical experts have implications for the content and organization of their knowledge, and the processes by which they use this knowledge to solve problems and make decisions. Section 5 of this report describes how our theory of expert knowledge can be adapted and applied to the unique requirements of executive knowledge.

A theory of the differences between experts and executives can also be used to identify experts who show executive aptitude, as well as for developing training methods that introduce experts to the kinds of thinking that will be required of them should they become executives.

2.4 Metacognitive Skills and Executive Performance

Interview data suggest that executives are consciously aware of the differences between their own approach to planning and problem solving and the approach taken by non-executives. We hypothesize that this very awareness is a key factor in their abilities. Executives deliberately set out to think globally, to look for the long term, to adopt multiple perspectives. This explicit strategy in turn facilitates development and refinement of these executive abilities.

Cognition directed at the process of cognition is called metacognition. Metacognition has become an increasingly active area of research in recent years (Forrest-Pressley, et al., (Eds.) 1985). Most of this literature has been directed at the educational development of children. But the need to move beyond this focus to adult metacognition is being recognized (Yussen, 1985).

A number of authors have pointed out the role of metacognition in giftedness (cf., Shore, 1986). Gifted children appear to have developed metacognitive strategies that facilitate learning: they have learned how to learn. Meta-cognitive training is increasingly stressed in discussions of programs for the gifted. Metacognitive abilities are not measured by standard intelligence tests, but we hypothesize that they will turn out to correlate better with executive performance in later life than do intelligence tests. We suspect that executives are like gifted children in that they have developed especially effective metacognitive strategies.

There is evidence that while metacognitive ability may develop spontaneously in gifted children, it can be developed with explicit training in normal and even learning disabled children.

Moreover, explicit metacognitive training has led to dramatic improvements in performance and learning ability in learning disabled children (cf., Feuerstein, 1986). These findings suggest a key role for metacognitive ability in learning. They also suggest that metacognitive training may be effective at improving performance at all levels of natural ability.

Most research on metacognition has involved children, and has focused on puzzle-like problems of the kind children see in school. Yussen (1985) has pointed out the need for research with adults. For research with adults, moving from puzzles to purposive planning problems will be essential. We concur with this assessment of the need for more study with adults. We conjecture that metacognitive strategy will turn out to be a key ingredient in a theory of executive performance. We also hypothesize that metacognitive instruction will become an effective tool for executive development. These issues are addressed further in Sections 5 and 6.

3.0 CURRENT STATUS OF ARMY EXECUTIVE DEVELOPMENT TRAINING

The Army has long recognized that a critical part of the leader development process is the growth of the decision-making and thinking skills required of executives. Research has shown that executive-level skills are different than those required at mid- and lower-levels. In the civilian sector, innovative teaching approaches include strategic management simulations such as those developed by Hay Systems, Inc. (Ingber, 1984), and Looking Glass, developed by the Center for Creative Leadership (Petre, 1984). In the military sector, each of the major military educational institutions with executive-level programs (e.g., National Defense University, Defense Systems Management College) has developed its own unique, innovative teaching ideas, but what is lacking is a consistent set of theory-based and validated techniques for teaching the skills.

3.1 Decision Domains

In the military, we can classify decision domains into three broad categories. These domains span both the mid-level and executive level decision making. Clearly, the boundaries among categories are fuzzy and there is considerable overlap. The basis for the categories is the general skills needed to make decisions in the specified domains. These categories are:

Program management decision domain: This would include decisions that are typically focused on financial management, resource allocation, systems acquisition, project management, planning/programming/budgeting system, etc. The bulk of this management is done at the mid-levels rather than the executive level. Skills needed are more managerial than leadership oriented. There is a high emphasis on quantitative methods, and advanced degrees in analytical and administrative sciences are most helpful. High-level issues such as the politics of systems acquisition are also critical. This domain is the central focus of courses taught at the Defense Systems Management College (DSMC) and the Industrial College of the Armed Forces (ICAF). Skills involving the overall management of military functions such as manpower and personnel training, etc. are included in this category.

Land warfare decision domain: This would include higher-level tactical/operational decision making at the corps level and above. There is a heavy emphasis on decisions relating to strategic concepts, national security, and the conduct of land warfare with the focus being on the battlefield. Skills needed included combat decision making, both in preparation for and in execution of division and higher operations. This domain is the central focus of the U.S. Army War College (USAWC).

National security decision domain: Decision making in this domain emphasizes the integration of military and foreign policy, means of avoiding armed conflict, international relations, and national security. The focus is off the battlefield and on the national planning issues. This domain is the central focus of the National War College (NWC).

3.2 Military Schools

The military school system provides formal training in skills and decision making processes that will be required of senior officers. Military schools providing executive education include the Defense Systems Management College (DSMC), the U.S. Army War College (USAWC), and the National Defense University (NDU). It should be noted that formal training of military officers essentially ends at the one-star or equivalent level, before they reach the executive level of functioning. After that, informal processes such as coaching, mentoring and counseling take over (Jaques, et al., 1986). As noted below, this has important implications for training. First, school training needs to focus on developing the precursors of executive skills. Second, executive development at the later stages will need to focus on support mechanisms for enhancing and increasing the effectiveness of coaching, mentoring and counseling relationships.

3.2.1 Defense Systems Management College (DSMC). DSMC focuses on program management and systems acquisition. Three courses are referred to as executive-level courses:

Executive Refresher Course in Acquisition Management is a 2-week course designed to "provide an understanding of perspectives and positions of key decision makers from the legislative and executive branches of government and the defense industry" (DSMC Catalogue, 1989). The course emphasizes major decisions required by DOD directives and instructions. Topics include: the defense systems environment, ethics in government, the decision-making process, and policy analysis. Teaching techniques include lecture/discussion and guest lecturers from acquisition commands, the primary defense industry, and OSD. The audience is military officers in the grade O-6 and above and DOD civilians in the grade of GS-15 and above.

Systems Acquisition Management for General/Flag Officers is a 4-1/2-day seminar for officers who will be expected to play a major role in acquisition programs. It is designed to update participants with the environment on which systems acquisition takes place, and with the functions, responsibilities, and problems of the DOD program manager. The seminar covers recent legislative and executive actions that affect weapons systems acquisitions, management policy and resource allocation policy, the planning/programming/budgeting system, and influences on the acquisition process (e.g., OSD, GAO, Congress). The seminar is

taught as a mixture of lectures and discussion sessions, with daily sessions in "lessons learned" from general or flag-officer program managers. Defense industry perspectives are shared and executives from OSD present specific issues. The course is open to those who hold or have been selected for the rank of general or flag officer, civilians within the Senior Executive Service, or persons of the vice-presidential level of industry.

Executive Management Course is designed to focus on practical and current management concerns and is intended for senior individuals who are not graduates of the DSMC Program Manager's Course but are assigned in the systems acquisition community. The 3-week course is divided into three major sections (fundamentals and concepts, systems acquisition environment, and current initiatives). Curriculum centers around sharing the acquisition experience, understanding service perspectives, and encouraging innovative ideas in program management. Teaching techniques include visits by PMs and representatives of DOD offices, a management simulation called Looking Glass, problem-solving case studies, lectures, and discussion. The course is open to the grades of O-6 or GS/GM-15 and above.

3.2.2 U.S. Army War College (USAWC). The Army War College prepares its graduates for senior command and staff positions by promoting an understanding of the art and science of land warfare. Students are provided with an understanding of decision-making processes within DOD to include management skills and analytic techniques, of national and international environment; and of national security policy formulation. Students must be in the grade of O-5 or above or comparable civilian status.

3.2.3 The National Defense University. This is the senior joint educational institution operating under the direction of the Joint Chiefs of Staff. It includes the National War College (NWC) and the Industrial College of the Armed Forces (ICAF). It is located at Fort McNair, Washington, DC.

National War College. The mission of the NWC is "to conduct a course of study of those military, economic, scientific, political, psychological, and social factors that are essential parts of national security" (NDU Catalogue, 1987-1988). It is a 10-month course focusing on national strategy and decision making, international relations, and use of military power. Decision making is taught at the strategic- and policy-level with heavy emphasis on the political aspects of military decision making from a joint, multiservice perspective.

Industrial College of the Armed Forces (ICAF). The mission of ICAF is to conduct courses in "national resources under current and predicted environments. These studies will include both national and world interrelated military, economic, political,

scientific, and social factors" (NDU Catalogue, 1987-1988). The entire ICAF program emphasizes development of decision-making skills and the antecedent skills. Graduates are prepared for roles in the national and international security structure. Decision-making processes are oriented toward: managing resources, manpower, money, and materials; organizations and processes involved in the determination of the total requirements of national security; and the problems of the national economy. The core program of ICAF is designed to develop graduates into executives who have the skills and perceptions needed by senior-level government leaders and managers concerned with national security.

The NDU also presents a National Security Management Program (NSM) that includes offerings from NWC and ICAF. The NSM program is designed to prepare "executives" for roles in command management and for responsibilities in a joint security setting. The NSM program is taught in a seminar and a correspondence course format.

4.0 OBSERVATION OF CRISIS DECISION EXERCISE

4.1 The Crisis Decision Exercise

The Crisis Decision Exercise (CDE) is the culmination of students' tour at the National Defense University. It is a politico-military simulation that brings together students from the National War College (NWC) and the Industrial College of the Armed Forces (ICAF). The exercise gives students hands-on experience in making national security decisions. Students take on the roles of staff members supporting the National Security Advisor, who is played by the faculty seminar leader. As the simulation progresses, a state of severe global tension rapidly develops into a global crisis. Students must work together to assess the world situation, define and prioritize U.S. interests and objectives, recommend what the U.S. should do, and evaluate the risks associated with their recommendations.

The game begins with a strategy session on Day 1, in which the students assess the world situation as described in a scenario document provided to them before the simulation starts. At the end of each day, they brief the faculty seminar leader on their recommendations. Based on the students' responses, the faculty seminar leader chooses an appropriate follow-on scenario for the following day, by tailoring one of a set of preplanned scenario branches as necessary to respond to the students' actions. At the beginning of each morning's session, the students are informed of new developments that occurred during the month of elapsed time since the previous day's session. The final day's session ends with a critique by the faculty seminar leader of the students' decision making processes.

A brief description of the scenario used in the 1989 Crisis Decision Exercise follows.

Day 1: Students are presented with a video describing how events have unfolded between 1989 and 1991. Several theaters are discussed including Europe, Central America, South West Asia, South East Asia and the Philippines. Tensions exist worldwide, with the most significant events occurring in Europe, Central America, and Southwest Asia. The European situation has become quite tense since Gorbachev has been replaced by a more anti-American, hard-liner member of the Communist party. Tensions exist in both Nicaragua and Panama. The Middle East continues to exhibit turmoil, with a precarious cease fire holding after a "summer war" between Israel, and Syria and Iraq. Students are instructed to review the changes in the world situation, establish U.S. policies and objectives and decide what mobilization measures to take.

Day 2: The Soviet Union has launched an attack into Iran in response to hostilities initiated by Iran. In addition, Soviets

are in the process of establishing a reconnaissance base in Nicaragua. Hostility towards Americans stationed in Panama is building. Again, students are instructed to determine what U.S. interests are at stake, if any, and make recommendations for a U.S. response to these events.

Days 3 and 4: The Soviets launch an attack into Norway, a NATO ally. The other theaters have stabilized somewhat, although the Soviets continue operations in Iran. At this time, commitment from NATO countries against this attack is uncertain. Students must determine the Soviet objectives and intentions beyond the Norway invasion, and devise a response strategy.

Day 5: While the Soviets continue to occupy northern Norway and Iran, the friendly position is somewhat more favorable, and conflict termination may be more likely. Students focus this day on developing plans for conflict termination.

4.2 Purpose of Observational Study

The observational study undertaken for this project was designed to assess the decision making processes of graduating NDU students and compare them to the processes characteristic of executives, which are described in Section 2 of this report. The findings of this study are intended to support the Army's goal of improving executive development in the following ways.

Observing the exercise enabled us to map out the thought processes and decision making strategies of graduating NDU students. Similarities and differences from executives were identified. This enabled us to assess what executive-level skills students appear already to be developing, and which need further work. This assessment has given rise to two tangible results. First is a set of recommendations of areas that might be given more emphasis if future students are to graduate with a more highly developed set of precursors to executive skills. Second is the foundation of a theory of executive development, of how the cognitive structures characteristic of executives grow out of the structures found in individuals at lower levels. A well developed developmental theory can be a valuable tool for designing both school curricula and on-the-job executive development opportunities.

It is important to state the limitations of this research. We attended the exercise as observers and not as experimenters. We were therefore unable to rigorously test our observations by experimental manipulation. Because we were not able to ask clarifying questions, our theory development had to rely on extrapolation based on observation.

Some of the behaviors we observed may have been an artifact of the exercise scenario itself. Specifically, the students were

instructed to focus on particular issues and come up with answers to specific questions. To the extent that this exercise focus differs from the direction they would have received had they really been staff assistants to the National Security Advisor, their decision making processes may have been altered. In addition, there was severe time compression. Each day of the exercise corresponded to about a month of real time. This too may have altered their decision making processes.

In addition, some of the students' behaviors may have been driven by the faculty seminar leaders. Based on our observations, some leaders played a passive role, allowing the students to operate autonomously, while others played a more active role in directing the students. In the session we observed, the faculty seminar leader left the students mostly on their own, except for general instructions at the beginning of the session and a critique at the end.

We offer some suggestions regarding the possible artifacts mentioned above. A caveat to these suggestions is that we have little information regarding the teaching practices at these schools and their priorities.

One way to address the response demands placed on students by having them answer specific questions with each day's materials is to utilize a more open-ended format (i.e., present the situation and have the students decide what issues are important). This may be especially useful if the exercise is to be used as an evaluation tool rather than a teaching tool. If the scenario is to be used as a teaching tool, such focusing questions may be important to let students know what issues are important. However, it seems reasonable that the "teaching" part should come during the course while the "evaluation" part should come at the end (i.e., at the end of the course, the students should be evaluated in terms of whether they can determine the relevant issues in a non-well-formed problem environment -- much the way an executive would). We recommend that the questions that the student be asked to address relate to realistic requirements that would be placed on them in a real-world setting.

There may be no good solution for addressing the time compression issue. In the exercise, scenario events evolved over months, while the students made decisions over the course of a few days. Recent work at Decision Science Consortium (Adelman, 1990) suggests that the proximity of information in an evolving situation (i.e., whether the information is presented close together or separated in time) has a significant effect on the judgments decision makers form regarding the situation. In other words, the students may be reacting differently to a situation that evolves rapidly in the classroom than real world policy makers might seeing the situation evolve slowly over a period of

months. Adelman found that people are less likely to detect changes in a situation when they occur gradually as opposed to more rapidly. As a result, the decision maker may be less likely to respond to those changes. Conversely, a decision maker observing an event evolve too rapidly (as is the case in the classroom environment) may overreact and generate a solution that they might otherwise reject.

Research by Leddo et al. (1989) suggests that time pressure causes decision makers to pay less attention to uncertainty, but make more conservative decisions. Loewenstein and Linville (1986) suggest that people become more pessimistic under time pressure. Research in progress by Leddo et al. (1990) suggests that the effects of time pressure are largely mediated by lack of uncertainty resolution. The implications of this work for the exercise scenario are twofold--first, students need to be reminded that the situation is evolving more slowly than it appears. Second, a greater emphasis must be placed on providing the students with the means of uncertainty reduction that would occur had they had the months of intelligence collection and analysis that would be available in the real world.

Finally, different seminar leaders played different roles in terms of the leadership and intervention they offered. There are a number of possibilities here, all of which relate to the goals of the exercise. If the goal of the exercise is evaluation rather than teaching, then a less directive seminar leader may be appropriate. However, the more directive instructor may be a better teacher. If this is the case (and it could be determined by comparing evaluations of students across the different classes and types of teachers), then it may be advisable to have a directive instructor teach the class, but a less directive instructor conduct the final exercise. Of course, if the goal of the exercise is to maximize group performance, then it may be desirable to have the directive leader conduct the exercise. This has implications for the real world as well. There may be an optimal level of directiveness for a policy making group leader. This level may correspond to the amount of divisiveness of the group. As the group polarizes (as we saw in the exercise), the role of a leader increases in order to keep the group focused and build consensus.

The combined effect of exercise and scenario artifacts coupled with an inability to clarify observations or experimentally intervene limits the degree to which our conclusions can be regarded as rigorous and generalizable. Nevertheless, our conclusions form the basis of a theory which can be verified by more extensive observation and experiment.

4.3 A Knowledge-Based Methodology for Evaluating Decision Processes

Our goal in observing the Crisis Decision Exercise (CDE) was not just to identify the decision making processes students use in the exercise, but also to infer the underlying knowledge that gives rise to these processes. This section describes our methodology for developing knowledge models of the students' decision making. Section 4.4.5 describes the knowledge models we constructed using our observations and the literature on how people reason and represent knowledge. Because we were limited to passive observation, rigorous validation of the knowledge models was not possible. Thus, the conclusions reported in Section 4.4.5 must be regarded as a preliminary theory of how graduating NDU students conceptualize and approach the solution of the problems they encounter in the CDE. More research is required to validate the theory and test its generality.

We are primarily interested in three knowledge types and how they interact and link up with one another. First are the goals or objectives articulated by the students. Second are the plans and procedures students use to carry out goals and objectives. Third is causal knowledge: knowledge about why events occur and why plans support the achievement of goals.

Our INKS framework has implications for how goals, plans and causal models are organized hierarchically and interconnected. Goals are at the top of the hierarchy and organize existing plans and help drive the creation of new plans. The connection between goals and plans is mediated by causal mental models which describe how goal-relevant (and other) outcomes are produced in the decision environment. Hence, the goals drive the desired outcomes and the causal models drive the specific actions undertaken in plans. Hence, the hierarchical organization is goals, causal outcomes, and plans.

Interestingly, executives often discover that they cannot meet all their goals or that new goals arise as they contemplate plans (cf., Anderson, 1983). We argue that causal mental models serve as a valuable feedback mechanism to the evaluation of goals. An executive may start with a general goal (e.g., unify the two Germanies). When he/she runs his/her mental model to see how this might occur in the existing environment, he/she may discover additional goal-relevant outcomes (e.g., economic problems, resistance by the Soviet Union). This gives the executive new considerations and new goals which must be taken into account, requiring that the original set of goals be tailored while at the same time there are new goals which must be dealt with.

As important to cognition as the type and content of knowledge is how knowledge is accessed and brought to bear on a problem or decision. Knowledge is accessed via links to events in the

environment and to other knowledge being used by the problem solver. Different link structures can lead to different cognitive strategies. For example, for one decision maker, knowledge about event patterns may be tightly linked to plans for dealing with the events; for another, plans may be accessed via goals and concretized using knowledge about the event patterns. Given a Soviet attack on Norway, the first decision maker may immediately call up and begin acting on a plan for military retaliation. The second decision maker will relate the attack report to his global goals (maintain world peace, prevent Soviet expansion, maintain the NATO alliance, etc.) and begin considering plans to achieve these goals in the context of the Soviet attack. The first strategy is often observed in highly practiced experts (cf., Larkin, 1981), and is a very efficient way to deal with stereotyped situations. The second strategy is more flexible and enables the decision maker to respond more appropriately to novel problems.

Given this background regarding the types of knowledge we use in our modeling approach, we now outline our knowledge mapping methodology. The "on-line" or real time component is straightforward: the observer records the major dialogue that occurs during the decision making process. Because the observer will not be able to record everything he/she hears (unless trained stenographer or able to use tape recorders, videotapes, etc.), he/she should focus on the major issues. In particular, the observer should record dialogue relating to the knowledge types discussed above and the interactions among them. This requires that the observer be familiar with the different types of knowledge. Table 2 is a description of the kinds of knowledge the observer should listen for and record. This coding scheme assumes an observer is familiar with the Integrated Knowledge Structures (INKS) model described in Section 2.3.2. An untrained observer can, of course, simply take notes on the exercise, but the quality of the information obtained from the record will be higher if the observer focuses on information related to INKS structures. We also recommend that data analysis and knowledge map construction be performed by the observer of the exercise, ideally soon enough afterward that the details of the exercise are still fresh. The observer is likely to have picked up cues from the general problem solving context that, although not explicitly recorded, serve as a context within which the meaning of the students' responses is more clearly understood.

Developing an INKS model is a process of construction and inference. We have found that decision makers in a naturalistic setting do not usually articulate all information necessary to fully flesh out an INKS model. For this reason, greater opportunity for the observer to interact with the participant enables knowledge structures to be inferred with greater confidence. When the observer can interact with the participants, he/she can probe more actively to fill in gaps in

Goals

- Utterer (the individual who mentioned the goal)
- Owner (whose goal is it)
- Category (e.g., military, political, economic, social, ethical...)
- Timeframe (e.g., short-term, long-term, number of years)
- Importance
- Link to
 - goals:
 - + interactions (esp. note more/less important than)
 - + instrument
 - + subgoal/supergoal
 - plans
 - mental models

Plans

- Actions
 - Temporal sequence: fixed/variable/time dependencies
- Triggering conditions
- Actors
- Props
- Outcomes (esp. do they play it out & predict outcomes?)
- Contingencies
- Flexibility in sequence/action
- Context
- Link to
 - goals
 - causal models

Causal Models

- Objects
- Forces
- Force/object interactions
- Outcomes
- Context
- Link to
 - Goals
 - Plans

Table 2. Coding Scheme for Knowledge-Based Data Collection.

the record. Leddo and Cohen (1989) describe a methodology for this probing process. Even when observation is passive, some of the benefits of probing can be gained if there is access to participants after conclusion of the problem solving session. Unfortunately, we were limited to passive observation in the CDE, and therefore had access to neither of these verification procedures.

The observer's record of the session is used to build a knowledge model of the decision process. Both the knowledge itself and the relationships among the different knowledge types are mapped out. As shown in Table 2, the knowledge we are mapping includes goals and objectives, strategies and plans for achieving these objectives, and causal knowledge of how these plans and actions achieve the objectives in the specific situations.

The observer should also be alert for links between different types of knowledge. For example, when a plan is articulated, does the student relate it to the goals the plan serves? Does he articulate causal information about how the plan achieves the goals? In particular, executives are skilled at "feeding back" the outcomes of the mental models they run on the goals they perceive themselves as having and using this feedback to reevaluate their goals and adapt their plans. In addition, the observer should note the degree of metacognitive awareness exhibited by students: to what extent do they analyze and critique the problem solving and planning strategies in which they are engaging?

We recommend mapping out the students' knowledge from the top down. Knowledge mapping begins by identifying students' general problem solving strategy, consisting of the broad steps followed by the students in solving a problem. This broad outline serves as a framework within which the rest of the students' knowledge can be placed. The broad outline may then be filled in with detailed procedures and content knowledge used in problem solution. It is important, to the extent this was observed, to include the rationale behind the students' strategy.

Students generally call upon different bodies of knowledge to support their problem solving. Developing a knowledge map involves (1) categorizing the statements they make by the type of knowledge being accessed; (2) organizing this knowledge into coherent structures; and (3) establishing the links by which the knowledge was accessed.

The first step in the analysis is to map out the students' goal structure. This is a set of goal relationships that drive how the students solved the problem. Different characteristics of goals include what they are, who has them, their relative importance, time dependencies, and goal relationships. Goal

relationships are subtle, but very important. Potential relationships include: instrumental (one goal helps to satisfy another); conflicting (achieving one prevents achievement of the other); subgoal (one goal is part of what is necessary to achieve a more major goal); consistent (achieving one goal is compatible with achieving another).

Many goals will be straightforward to identify and classify. Often information regarding them will occur in explicit statements of goals. Other goals can be inferred from the students' comments (e.g., "We need to accomplish this...", "We have got to be able to do....," "My number one priority is....").

Goal relationships can be inferred when students explicitly articulate the linkages between their goals (e.g., "but if we accomplish that, we won't be able to..."). In the absence of these explicit linkages, inferring goal relationships can be difficult.

Conflicting goal relationships are an important component of the CDE because the adversary's goals clearly conflict with one's own. This kind of conflicting goal is often obvious from the context of the discussion. The students may generate phrases like, "The enemy wants to do this, which will prevent us from accomplishing that", and vice versa.

Subgoals refer to goals that are components to a more major goal (i.e., the major goal is broken down into intermediate steps). For example, situation assessment may have as subgoals, infer enemy intent, determine current state of world, etc. The students might cue these with utterances such as, "We need to do this in order to do that.", "This is part of what we need to do.", etc.

In contrast to subgoals, which refer to components of other goals, instrumental goals refer to goals that need to be satisfied in order to achieve other goals. For example, while inferring enemy intentions might be a subgoal of situation assessment, developing an intelligence collection plan might be instrumental in inferring enemy intentions. Instrumental goals relate to how the students will achieve their goals, whereas subgoals relate to what the components of the major goals are. Hence, the observer infers instrumental goals from the plans that the students use to satisfy major or subgoals.

Consistent goals refer to goals which do not oppose each other and are often complementary. For example, students might cite goals of deterring war and strengthening ties with allied nations. These goals are consistent with each other, but neither is a subgoal of the other, nor are they instrumental to each other (although the goal of generating conflict with a common enemy could be considered instrumental to both). In general, it

will take some knowledge of the domain to assess whether goals are consistent with each other or whether they are in some other relationship.

One cannot necessarily infer that goals are consistent from the fact that a single person or organization holds them, nor can one infer that they are conflicting from the fact that adversaries hold them. For example, the goal of successful offensive engagements and the goal of minimizing attrition are usually held simultaneously by the same Army, but are in conflict: increasing the degree of accomplishment of one decreases accomplishment of the other. The United States and the Soviet Union, adversaries though they are, both hold the goal of preventing nuclear war.

Once the observer has mapped out the students' goals, he/she should focus on mapping out their general decision making strategy. The observer should look through the record of the problem solving session and pull out the major steps the students went through, leaving details to be filled in later. The map should include the processes the students went through, the order in which they occurred, and any interactions (e.g., the students may analyze the political tensions in a given sector of the world, decide how to respond to them, then repeat the process for another sector).

Next, the observer should map out the procedures the students used to carry out each step in the process. Of particular interest is the content of the procedures (what the students did), the order in which they occurred (including whether there appeared to be flexibility in the order), the triggering conditions, the actors (people involved in the procedures), the props (tools, equipment, etc.), any projected outcomes, and any explicit links to the goals.

Finally, causal relationships provide a rationale for why plans and problem solving strategies support goals. Causal connections can link both content knowledge and actions to goals. For example, setting up defensive positions on the edge of a tree line on the military crest of a hill is often an effective plan for defending forces. A causal justification for why this plan works is that hills provide good line of sight to enemy forces and tree lines provide good cover and concealment for retrograde of friendly forces. The rationale for these defensive positions not only relates to the benefits of line of sight and cover and concealment, but also to the attributes of woods and hills.

In mapping out these causal relationships, the observer notes the goal or subgoal to which the explanation provided by the students relates. Next, the causal relationship needs to take into account the situational and/or procedural factors involved (i.e., what the students are doing and/or using to accomplish the (sub)goal). Finally, the causal relationship needs to specify

how the situation and procedures lead to the attainment of the goal. It is desirable, if possible, to express the relationship in general terms (even as a formula) so that the causal relationship can be used to explain other actions or even make predictions regarding goal attainment given a similar set of circumstances.

4.4 Observational Findings

This section documents the findings of our observational study of the CDE. Sections 4.4.1 through 4.4.4 present anecdotal observations of the exercise and how students approached it. Section 4.4.5 applies the methodology presented in Section 4.3 to analyze the cognitive structures and strategies used by students in the CDE.

4.4.1 Classroom environment. The faculty seminar leader (FSL) for the observed group played a very passive role. He began each day with guidance to the group, updated the crisis exercise situation, answered questions, and then left the group to its own devices. He played the role of the head of the National Security Council, and when he returned to the room at a designated time, he was briefed in that capacity. This approach allowed the group to select their own direction and organization for the analysis efforts.

The seminar leader was chosen each day by the faculty leader, as was the recorder. These roles changed each day at the direction of the faculty leader. Both ICAF and NWC were represented in each of these roles. The student leader each day organized the group as he saw fit. In general, subgroups were organized on geographical area basis on the first day, and these subgroups were carried through the exercise by student leaders. ICAF and NWC were well mixed in the subgroups.

4.4.2. Seminar's method of operation. In all cases, the student leader quickly organized the group, assigned roles, tasks, and deadlines, and delegated responsibility to subgroup leaders. While there were many ways the group could have been organized, the geographic approach was dominant (Southwest Asia/Central Europe vs. Pacific/Central America).

Once the subgroups accomplished their tasks and the larger group reconvened, the student leader directed discussions trying to develop a consensus position. In most cases, the group discussions were not tightly focused and tended to jump from subject to subject. A common pattern was for individuals to state varying opinions followed by the group leader giving his perception of what needed to be done. While group leaders asked if there were dissenting opinions, very few objections were raised to the group leaders' positions.

While participation was broad and almost everyone contributed, the group was content to follow the student leader's role. No nonappointed leaders emerged, and there were few challenges to the directions that the student leader wanted to take.

The group began the seminar with two well-organized briefings on the situation and on the resource/mobilization issues. National interests, threats, objectives, etc., were discussed to include political, economic, and military issues.

During the 2nd - 4th days, the group broke into subgroups to address smaller parts of the problem, and reconvened to put together a briefing for the FSL. This provided opportunity for extensive student interaction, both in the subgroups and in the overall group. Some students were very active while others barely participated. While there was a lot of discussion, there was very little conflict or debate. In general, people would randomly express an idea, and if it wasn't countered, it was taken to be a consensus opinion. There was very little advocacy building and virtually no formal group consensus process.

In both the overall groups and the subgroups, the focus was very clearly on means rather than ends. They were very action oriented, particularly when it came to warfighting. While the seminar began with excellent briefings on objectives, interests, threats, etc., these quickly fell from focus. They occasionally reappeared, but usually as an after-the-fact crosscheck on the actions that had been taken. The analysis did not appear to be objective driven.

The questions in the student syllabus were marginally useful in keeping the group focused. Rather than using the questions to guide the effort, the discussion followed a more natural, emergent path. However, as a final crosscheck after conclusions had been reached, the group leaders used the syllabus questions as a checklist to see if each question had been addressed.

The mobilization guide had useful information, but comments from the group indicated that there was far too much to read. As a result, there wasn't much use made of it.

Based on our observations, the group sought very little information from external sources, and few messages were sent either during the work period or at the end of the day. Responses from the Control Cell were generally timely, but little information was received that the group found useful.

4.4.3 General assessment of the exercise. The exercise was challenging and interesting, and clearly created time stress on the students. It forced them to "divide and conquer" the problem and allocate time carefully. Often there wasn't enough time to integrate the component actions. The group recognized

uncertainties and ambiguities created by the exercise, but preferred to leave such issues unresolved rather than make best estimates and respond based on them. They were reluctant to make major moves without a clearer understanding of Soviet intent, the future, etc.

The students clearly were "in the weeds" and very action oriented, but that was at least in part due to the structure of the exercise. They were given very specific questions to address in the syllabus, and even though these questions didn't keep the group focused, they set the tone for what was expected. The exercise as it unfolded led the students to focus mainly on "what to do" rather than "what might happen," "why is this happening," and "what might the other side expect us to do"?

If the objective of the exercise is to create a forum in which the students can apply their coursework and integrate their skills, the CDE was successful. There were opportunities to appreciate joint service operations, and there were requirements to consider political and economic issues as well as military issues.

Group performance is very much driven by the role the FSL chooses to play. If he is very directive, poses many questions, and keeps the group focused, the exercise is more of a teaching tool. If the FSL takes a hands-off approach and lets the group move on its own, the exercise becomes more of an evaluative tool.

4.4.4 General comments on student decision making approach.
The students of both ICAF and NWC do an excellent job of managing group processes, delegating responsibility, organizing into working groups, and preparing the appropriate level of briefing. There was very little conflict observed during the exercise, and it is difficult to draw conclusions regarding consensus building and conflict management. However, it appears that it would be useful to include in the curriculum formal instruction on group decision processes, managing conflict, and consensus decision making. In informal conversations with the students during breaks in the exercise, ICAF students said they already receive such training; the NWC students said they didn't.

Both schools understand very well the system and environment in which they operate. The services worked together smoothly, learning from each other the unique strengths that each has to offer. There were discussions on political and economic issues as well as military issues, and the linkages among them became part of the discussions. However, there was a very heavy military flavor to the solution of the exercise, with most of the emphasis on warfighting actions. On numerous occasions, the group recognized that it was "doing the CINC's job," but couldn't get away from being very action oriented.

After the initial briefings, in which goals, objectives, threats, and interests were discussed in detail, there was very little focus on high level objectives. Rather than letting these objectives drive the analysis and dictate appropriate actions in a "top-down" fashion (as do typical executive decision makers), the analysis was very "bottom-up". That is, the emphasis was on what to do, and only after the fact, was there even a brief look at the impact on objectives. Along the same lines, there was very little discussion on looking at the problem from a "Red" viewpoint. It might have been useful to explore in more depth issues such as why the Soviets took their actions, how did they expect us to react, what do they really want, etc. Such wargaming of the other side can help drive the actions to be taken.

Similarly, from a "Blue" perspective, there was very little "what if" contingency analysis taking place. Group members would voice a proposed action, the group would typically voice no objections, and the leader would take that as consensus. There was a relatively short future time horizon considered, and very little "if this, then that" type of discussion. This was in part due to the short time available to complete the daily exercise tasks.

A great deal of time was spent on problem solution, and very little time on problem formulation. It might have been useful to spend more up front time bounding the problem, better defining goals and objectives, and, only then, deciding upon actions to be taken. In terms of problem solution, very few alternatives were posed. As indicated earlier, individuals typically would raise a suggested action, there was a little discussion, and then another issue would be raised. If there was no negative discussion, the leaders assumed that there was agreement. As a result, the solutions posed were "satisficing" in nature. That is, the action suggested crossed a threshold of acceptability, and as long as it stayed above threshold, it became the solution. There was never a series of competing alternatives on the table at the same time that could be compared and evaluated on specific criteria. Additionally, if a suggested action was a little offbeat, it was dismissed very quickly. Because only one idea stayed on the table at a time, and because unusual ideas were dismissed before they could be developed enough to be properly evaluated, the group process may have prevented innovative solutions from emerging.

4.4.5 Knowledge mapping of student participants. This section presents our findings about the knowledge structures that explain the planning and decision making behavior of students in the session we observed of the CDE. Because of our passive role at the exercise, these conclusions are necessarily tentative. Examples are given to illustrate the conclusions drawn. No attempt is made to develop a comprehensive knowledge map of the

entire Crisis Decision Exercise.

Goals and plans. After the initial briefings, students discussed high level objectives in detail. Table 3 shows the goals they identified. The global nature of these goals indicates that the students were aware of the broad range of concerns high level policy makers must consider. But they did little with these broad objectives beyond laying them out in the initial discussion. Their global objectives did not drive plan construction as they would for executives. Students constructed no plans explicitly directed at global objectives. Rather, plans were focused almost entirely on lower level tactical objectives. During plan development, there was little consideration of how proposed plans related to higher level objectives. There was sometimes a brief revisiting of global goals after the fact. It was clear that, although students were able to articulate global objectives, their knowledge was not organized in a way that linked these high level objectives to their more detailed and highly organized military planning knowledge.

When the group began focusing on planning at a lower, tactical level, this picture began to change (even when the plans did not involve military action, at which the students were expert). The plan structures articulated by the students did include a more detailed hierarchy of lower level goals explicitly related to the plan's main goal. Figure 2 shows the structure of a plan generated by students to induce the Soviets to withdraw after their attack on Norway. This was not a military plan, but its focus was a lower level tactical objective in response to an immediate crisis. Students did not relate the plan to long-term global objectives such as avoiding war, sustaining the NATO alliance, or engaging Soviet cooperation in the long term (Table 3).

General planning strategy. The dominant mode of operation was reactive planning in response to events or features of the situation. An event occurred, and a tactical goal was instantiated to respond to the immediate problem generated by the event. For example, the Soviet attack on Norway generated the goal of getting them out. On Day 1, before war had broken out, the students observed that NATO was currently in a position of excessive reliance on reserves. This generated the goal of reducing reliance on reserves. These reactive goals were often not stated explicitly. Often a situation would immediately generate a suggested action or plan, with the underlying goal remaining implicit.

Political Goals

Engage Soviet willingness to cooperate
Avoid conflict
Sustain NATO alliance

Military Goals

Deter war
Meet threats
Ensure survival
Freedom of navigation
Facilitate Allied nations providing their own defense
(instrumental goal) Cooperate with Allied nations on defense

Table 3. Goals Articulated By CDE Participants.

GOAL :
Get Soviets out of Norway

PLANNING STRUCTURE :
Starve Soviets out

PLANNING STRUCTURE :
Don't send Wheat

PLANNING STRUCTURE :
Stop U.S. Supply

PLANNING STRUCTURE :
Stop Argentinian Supply

PLANNING STRUCTURE :
Buy Argentinian Food

[Consequence : Flood U.S. market
Conflicting goal : Help U.S. farmers]

Figure 2. Planning Structure for Inducing Soviets to Leave Norway.

Figure 3 illustrates the planning cycle in response to the report that MIG-21's were headed toward Nicaragua. This event generated two reactive plans: a preemptive strike and a later strike after the MIGs had landed. The preemptive strike was discarded because of the potential consequence of inducing war with the Soviets. This was an instance in which a plan was evaluated after the fact in terms of one of the students' global objectives. But note that the plan was not initially constructed with this global objective in mind; the conflict with the global goal was noticed only after the plan was played out to infer its likely consequences.

Figure 4 contrasts this bottom-up, event oriented planning cycle with the top-down planning strategy used by executives. In event-oriented planning, an event instantiates the goal of responding to the immediate problem generated by the event. This activates a plan for correcting the problem. The goal activation is placed inside brackets in Figure 6 because this step may be bypassed. The plan may be aroused directly by the event, without explicit activation of the goal associated with the plan. (As evidence for this, CDE students often generated plans without explicitly referring to goals. Of course, the goal may have been aroused without being articulated. More research would be necessary for rigorous verification of the hypothesis of direct event-plan links.)

By contrast, in goal-driven planning the planner's top-level goals always remain active. An event is evaluated in terms of its impact on the high-level goals, and the plan for responding to the event is explicitly focused on the high-level goals.

Students showed little metacognitive awareness of their own planning strategies. The one exception to this was a student who was already a Colonel. This student suggested that the group adopt the strategy of first thinking militarily and then looking for political solutions. The Colonel did not articulate why he thought this was a good strategy to follow.

Causal knowledge. A key part of our theory of how knowledge is organized is that the goal-plan link is supported by a causal mental model of why the plan achieves the goal. We have found in earlier work (Leddo et al., 1988) that causal models often remain implicit during problem solving. A plan is invoked when its associated goal is aroused in the appropriate situation, but the associated mental model often does not become activated. Obtaining information about the mental models linking goals and plans is one area in which interaction with the subject whose knowledge is being mapped is crucial.

Students did "play out" their plans and predict plan outcomes. This prediction process probably involves some causal reasoning, although the students were seldom explicit about it. We saw

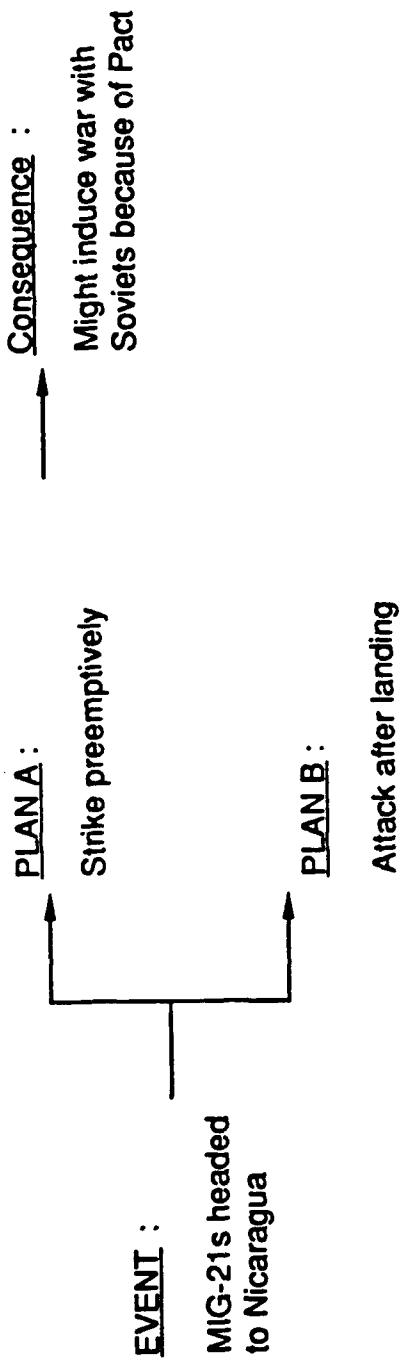


Figure 3 . Planning Cycle in Response to MIGs in Nicaragua.

CDE STUDENT PLANNING CYCLE



EXECUTIVE PLANNING CYCLE

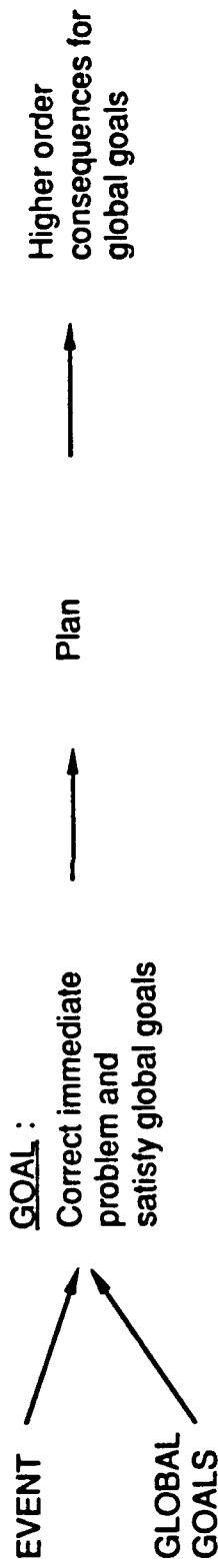


Figure 4 The Contrast: CDE Participant and Executive Planning Cycles.

little explicit analysis of the reasons why a plan was likely to succeed in a given situation, nor did we see much analysis of what might go wrong or why. Therefore, we were unable to construct explicit models of students' causal reasoning. Students also projected only immediate consequences of their plans. There was little analysis of how other parties might respond to the plan. One example of this was the lack of discussion of how a blockade of Cuba might be reacted to by Cuba itself. As noted above, students did consider the potential Soviet reaction to a preemptive strike on the MIGs headed toward Nicaragua. However, they did not consider Soviet response to a second plan for dealing with the MIGs, striking Nicaraguan bases after the planes landed.

Causal mental models linking plans and goals are invoked when plans fail and the planner needs to diagnose the failure to generate a response and develop a new knowledge structure to prevent the failure in the future. We have found in earlier research (Leddo and Govedich, 1986) that planners often fail to anticipate potential plan failures. This lack of "what-if" analysis means that causal mental models are accessed only when failures occur during implementation of the plan, and not at the initial planning stages. A similar lack of contingency analysis was found to occur with military planners under time stress (Leddo et al., 1987).

If the knowledge mapper can interact with his subjects, he/she can generate contingency planning by asking the subjects to state conditions under which the plan might fail, to explain why the plan failed, and to generate responses to the plan failure. We have developed interview techniques for stimulating contingency analysis (Cohen, 1989), but were unable to implement them in our CDE observation. We were able to observe very little causal analysis of why plans achieve goals and the conditions that would prevent goal achievement.

Contingency analysis and examination of second- and third-order effects is one of the key distinguishing features of the planning processes exhibited by executives. In effect, executives simulate plan failures mentally in order to develop more robust plans. More naive planners simply project ahead the most likely scenario, leaving themselves unprepared to deal with unforeseen plan failures. Military training stresses the importance of contingency planning. A great deal of emphasis goes into training officers to analyze when plans might fail and to generate contingency plans. As the research cited above demonstrates, this appears to be a difficult skill for people to acquire, and it appears to break down under time stress. To develop better ways of building this important skill, we need a deeper understanding of how cognitive structures make contingency planning difficult for most people, and what it is about executive knowledge organization that facilitates it.

General comments. Table 4 summarizes the main observations regarding the behaviors of the students participating in the Crisis Decision Exercise. As indicated earlier we observed several key differences between graduating NDU students and executives. First, the students planned reactively, generating tactical goals in response to events and developing plans to support the tactical goals. They considered the impact of these plans on their global objectives at best only after the fact. By contrast, executives plan from the top down, always planning for their global objectives. Second, the students did little contingency analysis. They projected the outcomes of their plans without considering factors that could go wrong and without developing backup plans that would allow recovery from failures. By contrast, executives use "what if" analysis to develop plans that are robust against failure. Third, students generated for the most part only immediate first-order consequences of their plans. By contrast, executives project higher order consequences, including the effects of their plans on other actors and their likely responses.

What is it about executive cognitive structures that differentiates them from those of the NDU students? We hypothesize two important differences. First, students' causal maps of the relationship of events and actions to their global objectives are not as well developed as are those of three- and four-star generals. Second, the causal knowledge they do have is not accessed when they generate their plans. The second problem is, we believe, more fundamental, because correcting it involves a basic change in how planning structures are organized and accessed. In Section 5 below, we argue that this ability comes with the development of an "executive layer" in the mind that organizes lower level knowledge around a set of global goals. This executive layer itself facilitates the gradual development of more complex causal maps which in turn help mediate the organization of the lower level planning and feature knowledge. The recommendations for executive development put forward in Section 6 are aimed toward developing this executive layer.

- Little debate; ideas not countered; taken as consensus opinion
- Action oriented; particularly with regard to warfighting
- Groups well-managed; including delegation and briefing preparation
- Solutions very military-oriented
- Decision making highly "bottom-up"; reacting to events rather than implementing goals
- Emphasis on problem solution, not problem formulation
- Broad policy objectives introduced early, but get lost in actual decision making
- Little "what-if" analysis

Table 4. Characteristics of Students' Behavior During the Crisis Decision Exercise.

5.0 A THEORY OF EXECUTIVE DECISION AND THINKING SKILLS

This section puts forward some preliminary concepts for a theory of the cognitive structures underlying executive decision and thinking skills. The ideas in this section represent insights derived from a combination of sources: literature on knowledge structures underlying human cognition, descriptive studies of executives and their unique characteristics, and our observations of how the decision making behavior of graduating NDU students compares with characteristic executive behavior. The ideas presented here are still in the formative stages. More research is needed to develop them further, to generate testable hypotheses to enable validation of the theory, and to test the hypotheses by some combination of experiment, observation, and simulation.

Executive level work focuses on articulating, communicating, and generating organizational commitment to a vision of the organization's purpose. By building shared ownership of the vision by the entire organization, the executive creates an environment in which the productive resources of lower levels are directed toward a common purpose. The executive must also gain cooperation and resources from outside the organization, in a multiplayer and multinational arena. The vision projected by the executive must be a long-term one, and the executive must communicate how shorter-term tactical operations support it. The executive must sustain his vision over a long period. By his actions he creates a future in which his vision becomes reality. The executive acts indirectly, shaping the future by influencing others to make his vision their own. He focuses on obtaining necessary resources from outside sources; allocating resources to enable lower levels of the organization to carry out plans that support his vision; and creating a motivational climate that inspires lower levels of the organization to direct their efforts in consonance with his vision.

The process of developing these executive capabilities extends throughout the executive's career. In the observational study reported above, graduating students from the National Defense University exhibited only limited instances of the kind of planning and decision making behavior characteristic of executives. Students at the Lt. Colonel and Colonel level were able to articulate a set of high level objectives that encompassed the broad range of objectives considered by executives. But the plans they constructed and the causal models they considered were focused on much lower level goals. While they were aware of the importance of the high level goals, they did not generate plans that addressed all their goals simultaneously. They tended not to consider second- and third-order effects of the plans they generated.

Our hypothesis is that the difference between these students and executives at the three- and four-star level is at most secondarily dependent on differences in factual knowledge--about military tactics, or politics, or economics. More important is how that knowledge is organized. We suspect (although verification was impossible due to our passive observational role) that students could if asked generate at least some second- and third-order consequences of their plans, and analyze at some level the relation of their tactical plans to their global objectives. Yet we saw little spontaneous planning beyond immediate goals and immediate consequences. As noted in Section 4, this may have been in part an artifact of the CDE itself. But we also suspect that the planning structures they used to generate plans were not as well linked to their global objectives and causal models as are those of executives. In the absence of direct, highly practiced links, a conscious, deliberate construction process would have been necessary to produce analyses in terms of higher order goals and higher order consequences. If the faculty seminar leader had exercised a more active and directive role, the students might have analyzed the problem more globally, but at some point the sheer complexity of the interactions among all the factors to consider might have overwhelmed them.

For executives, knowledge of high-level goals and the causal factors underlying their achievement is organized efficiently and linked directly to planning knowledge. Executives do not need painstakingly to reason out second- and third-order consequences of plans, nor do they need to analyze explicitly the implications of plans on their higher level goals. The executive is accustomed to placing planned actions within a broad context. The process seems intuitive and effortless, but is in fact the product of a long period of development. The goal of our research is to make a beginning at understanding how this development process operates, and to find ways to foster this development.

Marvin Minsky (1986) has drawn an analogy between the mind and a bureaucratic organization. According to his theory, intelligent behavior arises out of an interaction among lower-level cognitive processes, or agents, which could not in themselves be called intelligent. The key to intelligence, maintains Minsky, is in how these interactions are organized. One of Minsky's key theoretical tenets is Papert's Principle:

"Some of the most crucial steps in mental growth are based not simply on acquiring new skills, but on acquiring new administrative ways to use what one already knows." (Minsky, 1986; p. 102)

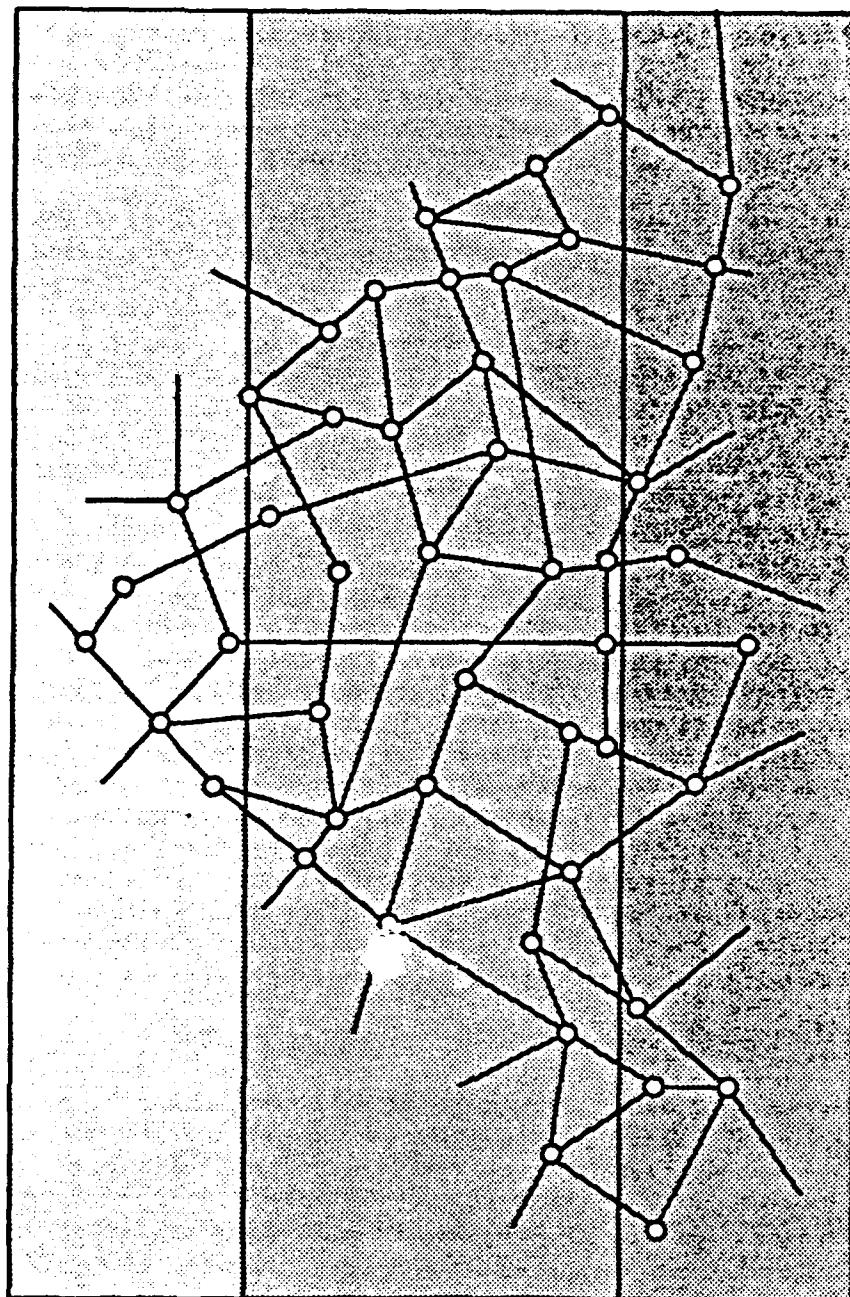
This statement is strongly reminiscent of our conjecture above that what graduating NDU students must develop further is not

primarily specific knowledge or skills, but cognitive structures that allow their knowledge and skills to be applied effectively. Thus, the important theoretical issue is identifying the cognitive organizing principles which enable executives to access and apply their knowledge.

Minsky explains the development of competence in the classic Piagetian water experiment in terms of the development of administrative "middle management" structures in the mind. In this experiment, a young child will judge a tall, thin container to have more water than a short, wide container, even when the child has observed equal amounts of water being poured into each container. Minsky hypothesizes two lower-level agencies in competition--one judging by height and one by conservation of quantity. These lower-level agents are weak and fallible: they can attack only a small part of the problem to be solved and they do not always give the correct answer. As the child matures, a middle manager learns to arbitrate the conflict between "taller" and "same amount" on the basis of a general principle that conservation of quantity dominates appearance. Middle manager agents know the capabilities of the lower-level agents, and can task them and arbitrate disputes among their outputs. Thus, a middle manager can organize a collection of individually weak and inadequate units into a powerful problem solver.

More powerful cognitive structures arise from increasingly complex bureaucratic structures of mental agents. Like bureaucracies of people, societies of mind organize direct-action agents to focus their efforts in a consonant direction. Higher-level agents direct and task lower-level agents, using a broad knowledge of their capabilities. Conflicts between agents are managed, by negotiation or by direct fiat. Manager agents monitor progress using summary measures of success at lower levels. Cognitive effort is redirected when it appears that the current plan is not succeeding. The degree of intelligence exhibited by the individual is a direct product of the organizational ability of the society of mind.

Pushing this analogy further, we may postulate levels in the society of mind corresponding to direct, organizational, and executive levels in bureaucratic hierarchies (Figure 5). The direct level handles simple, concrete plans to accomplish specific tasks. Causal knowledge at the direct level consists of concrete knowledge about how the forces influencing task accomplishment operate. The organizational level organizes the application of direct plans. Organizational-level agents do not possess a detailed understanding of causal dynamics at the direct level. Rather, organizational-level managers have a general understanding of the capabilities of lower-level agents and can measure the success or failure of lower-level plans. Causal mental models at the organizational level organize knowledge about how direct-level agencies work. Organizational-level plans



Executive layer:
Meta-goals & meta-plans
directing development of
causal map

Indirect layer:
Causal map linking goals
to plans & objects

Direct layer:
Concrete objects, goals,
plans

Figure 5 Hierarchical Organization of Mind Society.

still serve relatively focused and self-contained goals, although the means of goal accomplishment is indirect via tasking lower-level agencies.

The highest level in the society of mind is the executive level. The executive level is concerned with balancing the broad range of goals possessed by the individual. Individuals with a well-developed executive level possess a coherent vision of the direction of their lives. They are able to balance competing objectives in a way consonant with this overall vision. This ability to focus effort toward a coherent overall purpose has been termed self-discipline. It involves both the ability to suppress goals that compete with the achievement of the global purpose, and the ability to develop plans in which other goals complement rather than compete with the global purpose.

The executive level in the society of mind is analogous to the executive level in an organization. The executive level performs the following functions:

- Creates and sustains a coherent overall vision of the individual's direction in life or in a career;
- Considers a global perspective. Considers a long time horizon. Considers a broad range of objectives (career goals, family goals, community concerns, retirement, etc.);
- Balances and sets priorities among competing objectives;
- Arbitrates conflicts between strong but potentially competing objectives. The most effective conflict resolution involves negotiation and consensus building (i.e., developing plans that allow all objectives to be satisfied to some degree, while maintaining consonance with the overall purpose);
- Allocates cognitive resources among lower-level agencies within the mind;
- Obtains resources from outside the individual and brings them to bear on achieving the individual's global purpose.

This set of functions is very similar to the functions served by the executive level in an organization. On reflection, this is not very surprising. A common theme in cognitive science and artificial intelligence is that intelligent behavior evolves out of the coordinated interaction among simpler, less intelligent processes (cf., Hofstadter, 1980). If the processes are well coordinated, the organization is capable of behavior of a much higher degree of complexity than is any of the simpler units by itself. Similarly, a collection of human beings can, if well organized and managed, accomplish tasks and pursue goals of a much higher degree of complexity than any individual can

accomplish alone. Simpler mechanisms may well have evolved for both organizations of cognitive units and organizations of people.

Our understanding of the processes governing the emergence of complex behavior from simple subunits is still in its infancy, but is an active area of research (cf., McClelland and Rumelhart, 1986). We share with Minsky the belief that the study of human cognitive functioning and the study of organizations can benefit greatly from cross-fertilization of ideas, and that models developed in one area will provide fruitful analogies for models of the other area.

We hypothesize that individuals who reach the executive level in organizations of people are individuals who have a well-developed executive layer in their cognitive organizations. But this executive layer must be built upon a strong foundation. The power of a society of mind (as of an organization of people) depends on how interaction between the agencies comprising the society (including the executive agencies as well as the lower level agencies) is organized.

In speculating what sets so-called genius apart from ordinary intelligence, Minsky says:

"...in order to accumulate outstanding qualities, one needs unusually effective ways to learn. It's not enough to learn a lot; one also has to manage what one learns. Those masters have..."higher-order" expertise, which [helps] them organize and apply the things they learn... One child works out clever ways to arrange some blocks in rows and stacks; a second child plays at rearranging how it thinks... No one can see what the second child has done, and one may even get the false impression of lack of industry... But...this can lead to silent growth...later, we'll observe an awesome, qualitative change, with no apparent cause...[and call it] talent, aptitude, or genius." (Minsky, 1986, p. 80)

At some point during their development, those who become executives begin to "play at" learning how organizations function. While another employee carries out the task given to him as directed, the potential executive attempts to fit the giving of the task and its execution into a larger picture. Why was this particular task given? What higher-level goals does it serve for my manager, and the managers above him? Does it advance or conflict with the overall organizational objectives (with the CEO's broad vision)? How could I tailor its execution in a way that better serves the goals of those higher up in the organization, and makes me more visible as a target for promotion? Irrespective of surface appearances, what is the real power structure of the organization, and how does this task fit into it?

Notice a key feature of how the potential executive's cognitive processes function: he is explicitly and consciously trying to develop a broader and more encompassing causal map. The potential executive is always trying to go beyond his immediate role and the immediate task at hand. He attempts to build a causal map of the larger organizational structure and fit his immediate role and tasks into this causal map. Of course, when he is not yet at the executive level, the causal map he develops will not be as complex as an executive's, but like the second child in Minsky's quote, he is building the foundation required for progress at a later stage in his career. And again like Minsky's second child, the pre-executive's fascination with building a mental model of the organization is likely not to be extrinsically rewarded at lower organizational levels (Jaques et al., 1986). To become an executive, he must either find this mental model building intrinsically rewarding, or be fortunate enough to have a mentor who encourages it and points out its long-term value.

Long before they actually become executives, we hypothesize that those with executive potential acquire certain key pieces of metacognitive knowledge as part of the executive layer of their mind societies. First is a meta-goal:

Look beyond surface appearances for the "deep structure" in any situation. Develop a causal model of how this "deep structure" operates.

Like Minsky's second child, executives explicitly try to rearrange how they think. This rearrangement in executives takes the form of trying to organize their knowledge about how their organization functions around increasingly powerful causal maps that capture deep structure.

Second, executives have a meta-plan, or plan for building plans, that can be described qualitatively as follows:

In any situation, do not plan just for the immediate objective. Link all plans to your global, long-term objectives for the organization. Modify the plan until it attains the immediate objective but also positions the organization to achieve these global objectives.

Finally, executives have another meta-plan, this one a plan for evaluating plans and projecting their consequences:

When evaluating a plan, look for indirect consequences and possible failure conditions. Modify the plan to correct for undesirable indirect consequences and take advantage of potential indirect benefits. Develop contingencies to deal with potential failures. Take the perspective of the "other guy" and anticipate how he will react to the plan. Modify the

plan to include actions to improve its reception by other parties.

We have hypothesized that executives have a well-developed executive layer in their mind societies. Like an executive in a bureaucracy, the executive layer's role is to organize the activities of lower layers around a common vision. The ability to develop this executive layer depends on the acquisition of the meta-goal of building a causal map of the deep structure in situations, the meta-plan of planning within as broad a context as possible, and the meta-plan of evaluating plans by considering indirect consequences, failure contingencies, and effects on others.

The executive layer also must, we have stated, be built upon a well-organized substrate of lower-level agencies. The power of a mind depends on the management structure at all levels--the ability of the mind to access the right knowledge and put it to good use. Although we are at a very early stage of research on principles of interaction, it is possible to sketch out some preliminary ideas on important determinants of effective mind organization (with emphasis on the role of the mind's executive layer). Important research issues include the following:

1. Executive control of lower-level agencies. The executive layer sets policy. It establishes priorities and provides resources to lower-level agencies. In organizations of people, different mechanisms for this exist. The executive can influence the goals of lower-level agencies by setting up rewards and punishments. He/she can dictate or influence the actions of the lower agencies. He/she can give or take away resources, which influences the ability of lower-level agencies to carry out their goals. To what extent are analogues to each of these mechanisms important in cognition? What are the consequences of different control mechanisms? In organizations of people, micromanagement of lower levels (i.e., explicitly setting their agenda) not only wastes and often misdirects resources, but also creates resentment. Is there a fruitful analogy in cognition to the intrinsic reward of self-direction? Are mental agents more productive when given the autonomy to pursue their own goals?
2. Executive information. The executive layer can operate effectively only when it has good and reliable information about the performance of lower-level agencies. But a deluge of detailed information cannot be assimilated. The executive layer requires that the information regarding how lower-level agencies are performing be processed. This processing needs to be informative in terms of how well the lower-level agencies are progressing toward the top-level goals. Often this is thought of as presenting "the bottom

line." Communicating the executive's vision to the lower-level agencies makes it more likely that the information they communicate upward will be valuable. Communication must thus flow both upward and downward. An important research issue is the kinds of organizational structure that facilitates communication of the executive's "global vision." Are there useful analogues in the society of mind to informal communications channels and "old boy" networks?

3. Executive goals, plans, and mental models. We have identified three key meta-structures that must be included in the executive layer. Are there others? The executive layer must have a high-level, global set of objectives. Plans must be related to these high-level objectives and to mental models of the causal factors leading to or preventing accomplishment of the high-level objectives. The organization will not function well unless these global goals are consonant with the goals of lower-level agents and of outside agents that can influence the success of plans. An important part of planning is to structure the situation to achieve the maximum degree of consonance. Mechanisms used by organizations of people include modifying the goals of subagents and outside agents, and the developing of win-win plans, and giving more resources to agents with consonant goals. Are there useful analogues to these mechanisms for societies of mind? The executive layer needs a good mental model of how lower-level and outside agencies work. This mental model must include an understanding of when the measures of progress available to the executive layer are likely to work well or poorly, and how they are likely to fail.

6.0 RECOMMENDATIONS FOR EXECUTIVE DEVELOPMENT TRAINING

6.1 Objective of Training

We have argued that the distinguishing feature of executives is not what they know, but how they organize and apply what they know. Particularly important to executive performance is what we have termed an "executive layer" in the hierarchy of cognitive structures. We have identified three key metacognitive structures in this executive layer:

Meta-Goal: Develop a causal model of the deep structure in any domain. Attempt to broaden perspective whenever possible.

Meta-Plan: Build plans to achieve global and long-term objectives. Tactical plans must fit in within a coherent global framework.

Meta-Plan: Anticipate and be prepared for nth order consequences and possible failure conditions.

Thus, the executive is always, we suspect usually consciously, attempting to develop a global causal map of his environment. Long before becoming an executive, he/she attempted to think more broadly than others at his/her level, to understand the environment and tasks within the broader framework of the organization as a whole and its interaction with its external environment. He/she is always alert for opportunities to further broaden this perspective, and for changes in the environment that mandate perspective broadening. (As an example, if Gorbachev is successful, the United States may need to change the focus of its strategic planning from a two-power model to a multi-power model in which the importance of and danger from the Soviet Union are reduced. Our best strategic planners, whatever their beliefs about whether and to what degree this change will materialize, are developing causal maps and contingency plans for the possibility.)

This causal map building activity supports the two meta-plans. In the always novel problems faced by the executive, good global planning requires a powerful causal map of what actions will bring about accomplishment of the global objectives. This causal map must also support inferences about indirect and long-term consequences of plans.

We have stated that an abstract understanding of the importance of the three meta-structures will not suffice to produce executive behavior. These structures must be well linked to lower-level tactical goals and tactical planning structures.

Although their analyses could not be expected to be as

sophisticated as those of three- and four-star general officers, the NDU students undoubtedly could, if asked, have generated higher-order consequences, considered political repercussions of military actions, and taken multiple perspectives. But there was little spontaneous analysis of this kind, even when the Faculty Seminar Leader admonished them to think more globally. This indicates that students' tactical planning knowledge might not be linked strongly enough to global goals or to high-level mental models of the causal relationship between plan outcomes and global goals. Explicit awareness of and attention to the three meta-structures can mediate the development of these necessary links.

Under the current system, executive layer structures and their links to lower-level structures are developed unsystematically, and only in a few individuals whom we label as having "executive proclivity." Why do some develop an executive layer and some not? There are those who argue that executives are born and not made--that only a few of us have the cognitive power necessary to develop the complex causal maps required for executive performance. Natural talent undoubtedly plays a role; the extent to which it determines executive potential is a matter for empirical study. But as important as raw talent is the discovery of our three pieces of meta-knowledge. For some, this discovery is itself a natural proclivity. These individuals find mental model building intrinsically rewarding. There are others who at some point in their careers have inferred the practical utility of executive-type metacognitive strategies. They have noticed over time that while there is little immediate extrinsic reward at lower levels (in fact, sometimes the opposite), those who practice these strategies go further in the long run. Often a mentor plays a key role in developing this awareness in young aspiring executives. The mentor can serve as a role model, and can point out to the student regularities he might not notice on his own (e.g., individuals who may be getting into trouble now, but are attracting the notice of higher-ups, and will probably go far).

Whatever the role of inborn talent in determining an individual's potential for executive level performance, we maintain that it is possible with proper training to enhance the process. Not all those who could reach executive ranks actually do. And not all those who do reach executive ranks learn to perform at the top of their potential range. Thus, we expect a good executive development program to have substantial impact on the quality of executive leadership in the Army.

Our research leads us to recommend that formal and informal executive development processes adopt as explicit goals to develop the executive-layer cognitive structures identified above and to link them to lower-level structures. To implement this recommendation properly, the creators of executive development

programs should themselves have a good causal map of how these executive level functions develop. Unfortunately, this issue has not been well studied. But insights are available from research in cognitive development, including research in the development of metacognitive skills. More research is needed, especially research targeted directly toward executives, to validate and extend the suggestions outlined below.

6.2 Recommendations for School Training

Military schools train officers below the general/flag officer level (or the civilian equivalent). Formal education essentially stops above this level. The schools' primary mission must be to prepare graduates for the positions they will be facing when they leave school, which are positions below the executive level as we have defined it. Yet the schools' mission also includes planting seeds for the skills they will need as officers move up the ranks. This aspect of the schools' mission takes on added importance because this is officers' last opportunity for formal school training.

We recommend instruction on problem formulation and top-down, goal-driven planning. Students should be instructed on how to establish goals and generate plans from them. Students should be able to structure problems according to the objectives which need to be met, rather than only the problems that need to be solved.

We recommend formal instruction on generating and evaluating several options as opposed to a strategy of finding only one good option. We recommend a strong focus on anticipating and planning for contingencies.

We recommend instruction on perspective taking. In particular, students need to understand the other side's position and how own actions impact on them. In particular, attention is needed to considering how the other side will respond and what we should do about it.

We recommend teaching students to be explicitly aware of their approach to planning and decision making, and encouraging them to adopt the meta-cognitive structures described in Section 6.1. Care must be taken in how this recommendation is implemented. We strongly recommend a practical problem-solving oriented approach to metacognitive instruction. Kuhn, et al. (1988) point out that practicing a strategy on specific problems "is likely to serve not only to perfect its execution but also to promote metacognitive awareness of the strategy itself... Paradoxically, then, exercise of strategies within very specific, content-delimited contexts may promote their generalization, while didactic teaching of the same strategies in more abstract, general form may fail to achieve this same end."

Thus, we recommend that students practice top-down problem solving, contingency analysis, Red-teaming, and perspective taking on a variety of concrete problem scenarios. During the discussion, the instructor should point out instances in which students are using the target meta-structures, and should explicitly encourage causal map building. This explicit meta-cognitive instruction should occur within the context of specific problems. Abstract lectures on metacognition in isolation are unlikely to be very effective. At best, this approach will lead to declarative knowledge that is not linked to concrete problem solving knowledge.

The problems used for metacognitive training should be targeted just beyond students' current comfort zone. If problems are too familiar, students will lapse into routine procedures and not access their developing metacognitive knowledge (c.f., Larkin, 1981; Kuhn, et al., 1988). (The cognitive psychology and cognitive science literatures (cf., Galambos, 1986) offer several techniques involving priming and categorization of instances that diagnose the extent to which people view problem cases as stereotypic or novel). If problems are too difficult, students will flounder completely. The instructor must then be aware of the tendency of students to narrow the problem scope to the familiar and then apply routine, compiled knowledge. The instructor must be proactive in keeping the discussion on the broad context, inducing students to devote attention to the novel and difficult aspects of the problem.

We recommend an instructional approach that avoids the dangers of too much and too little abstraction. Too much abstraction is evidenced by students failing to recognize the relevance of problem solving strategies or to link them to their concrete problem solving knowledge. Too little abstraction results when students practice on a wide range of examples without pointing out their commonalities. The results of this will be that some students will notice the commonalities and develop more general and powerful high-level structures that apply across a range of situations, but others may simply develop a repertoire of special purpose strategies and never be able to generalize beyond the specific contexts they have seen.

We recommend an interplay between abstract and concrete instruction. Students build abstract metacognitive structures by applying them in concrete situations, while being made explicitly aware of the general structures they are applying. We recommend that instruction in executive layer meta-structures have three components. First is an overview of what is going to be taught, why it is important, and how it fits into the larger objectives of the curriculum. The overview is a brief context setter, to establish a framework for the students to understand what they are learning. The overview presents the problem-solving context

(e.g., how to respond to the hypothetical overthrow of Corazon Aquino in the Philippines) and the planning strategies the students will be considering (e.g., various military, diplomatic, and economic options). The overview also describes briefly how this problem-solving session fits into the global goals of the curriculum--that is, what students are expected to gain from the lesson. (This latter aspect of the overview helps students to apply a global, top-down approach to their own learning experience.)

The second component is top-down instruction. The focus of top-down instruction is on tailoring general plans to work in specific situations. This approach helps students to concretize plans and differentiate situations in which they might be applicable. Students are given a problem in which a number of different objectives come into play (e.g., the Philippines example described above). They are also given one or more general planning strategies (e.g., military response; a combined military and diplomatic approach) and asked to develop these strategies in more detail for the current situation. They are asked to lay out their high-level objectives and analyze the situation and their plan in the light of these objectives. During top-down instruction, the instructor keeps students focused on global objectives, and stimulates causal analysis of why the plans do or do not achieve objectives. The instructor asks students to analyze which goals come into conflict, and asks them to generate ways to respond to the goal conflict. As they develop and tailor their plans, students are explicitly reminded to plan for their global objectives, to think about failure contingencies and indirect consequences, and to adopt multiple perspectives. Students would then be given feedback as to how well these plans would work in a realistic setting. The instructor would then help the students critique their plans and any failed outcomes in terms of how much the plans lacked these executive qualities and the extent to which these planning deficiencies could be linked to the outcome failures.

The third component is bottom-up instruction. In bottom-up instruction, rather than being given a plan and applying it to a situation, students are given a situation and asked to generate a plan in response to it. Here students are likely to revert to reactive planning. When they generate a potential plan, the instructor must remind them to think about their global objectives and how the plan impacts on them. Different plans generated in different situations are analyzed and compared for their commonalities. The student is given feedback regarding how well he/she has taken global objectives into account. This promotes generalization--the building of higher level abstract structures representing plan commonalities and the development of links from concrete plans to these abstract structures.

A combination of bottom-up and top-down instruction can be applied to develop analogical reasoning and the development of high-level generalizations. Students are presented with specific problems and asked to reach conclusions about principles or "lessons learned" suggested by the problems. Here, the students are being asked to generalize from their experience with the problems. Once they have developed some generalizations, top-down links could be developed by asking them to generate similar problems embodying the same principles. Students are then given additional problems which embody similar themes. These problems begin as being very similar to the original problem and gradually lose their "surface" similarity. The point here is that students gradually learn to recognize common themes across contexts with less and less priming.

6.3 Executive Development Beyond School Education

Jaques, et al. (1986) point out that the most critical need in officer development is assistance with the transition from two-star to three-star level. This is the transition from organizational to executive leadership, and the point at which a well-developed set of executive layer metacognitive skills becomes essential to success. Officers interviewed by Jaques, et al. complained of being thrown in at the deep end, of being thrust into situations and responsibilities for which they had not been properly prepared.

Our first recommendation for managing this difficult transition is to begin preparation well in advance. One key component of this preparation process is implementing the recommendations discussed in Section 6.2 for school education. This will begin the process, at least in those with the requisite potential and proclivity, of building the necessary executive layer cognitive structures. But these beginnings need to be nurtured beyond the school years. We pointed out in Section 2.2 that reliable predictors of executive potential are becoming available. Individuals with executive potential should be singled out for special attention and training.

Jaques, et al. (1986) recommend several mechanisms for this special training. Most important is strengthening existing coaching, mentoring, and counseling relationships. Coaching is the process of development and training carried out by one's superior as part of regular performance appraisal. Mentoring is a special relationship between a young officer and an older officer above the level of immediate superior. Counseling is provided by specialists in career development, professional assessment, or psychology.

Jaques, et al. also recommend special assignments that stretch officers beyond their current level of capability. As noted in Section 6.1, these assignments should be just enough beyond the

current level to be challenging but not overwhelming.

A final mechanism recommended by Jaques, et al. is opportunities for time away from direct job responsibilities. This can include mini-sabbaticals in which the officer studies or reflects on his assignment, long-term goals, and long-term strategies. It can also include short courses to broaden the executive's range of experience. Finally, when transfer time comes, the officer can be given the opportunity to leave his post early, to reflect on the transition and mentally prepare himself for his new assignment.

Beyond simply providing these mechanisms for career development beyond school, the Army needs to provide a context that facilitates their being used effectively. In particular, there must be mechanisms for disseminating what has been learned about executive development to aspiring executives and to their coaches and mentors. An important step would be the development of an Army manual on leadership at the executive level. The manual would be an important resource both for potential executives and for coaches and mentors who wish to groom their proteges for executive leadership. A second step would be to provide the kind of instruction described in Section 6.2, but at a higher level, in the form of mini-courses (from a few days to two weeks). Such courses could be added to the existing repertoire of mini-courses at the executive level. These courses would be open both to one- and two-star general officers preparing for the transition to executive level, and to three- and four-star general officers who wished to gain a broader understanding of their own leadership position and to become more effective coaches and mentors. Like the school courses proposed in Section 6.1, these mini-courses would stress the development of executive layer meta-structures. They would focus on conscious awareness of these meta-structures (to facilitate coaching and mentoring), and on specific examples of how they are applied in specific planning, problem solving, or decision making settings.

7.0 RECOMMENDATIONS FOR FUTURE RESEARCH IN EXECUTIVE DEVELOPMENT

This project has developed a preliminary theory, based on analysis of interview and observational data, of the cognitive structures underlying executive behavior and how these structures differ from those of non-executives. The work reported here points to two major directions for future research in executive development.

7.1 Validation of Findings

We have postulated that executives possess three key meta-structures, and that executive development should focus on attempting to develop these meta-structures in potential executives. An important research area is validation of these hypotheses. We recommend the development of an instrument that measures the presence or absence of the meta-structures identified in our research. This instrument can be administered to executives and non-executives and the results compared. It would also be useful to correlate the presence of executive level meta-structures with scores on other measures of executive potential like the CPA, and with subjective assessments of executive potential by an officer's superiors.

Our recommendations for training also need to be validated. We recommend implementing instructional interventions such as the ones outlined in Section 6.2, and comparing educational outcomes for students who did and did not receive the interventions. Outcome testing can measure the presence of the target meta-structures, or can be in the form of some other measure of executive potential such as the CPA.

7.2 Further Theory Development

The theory outlined here is still in its preliminary stages. One of the major insights of our time is that the interaction of simple parts can yield complex behavior, and that the type of behavior that emerges depends on how the interactions among the simple parts is structured. But our understanding of how these processes work is still in the preliminary stages. We suspect that computational models will serve as a useful research tools in the study of societies of mind as well as of societies of people. Also important will be observational studies to validate existing computational models and suggest directions for future computational modeling.

In Section 5 we identified three research questions that need to be addressed to develop further a theory of how the executive layer of the mind is organized. These issues are:

1. What mechanisms are available to the executive layer to control lower-level agencies?

2. How are information flows between executive and lower layers structured?
3. What goal and planning structures and causal maps are present at the executive level, how are they linked, and how do they interact with lower levels?

Beyond a theory of how the executive layer functions, we need a theory of how it develops. Observational studies of individuals at various stages of development can be used to identify skills characteristic of each stage. But not all individuals at a stage go on to the next. We need to determine which skills are predictive of upward mobility. Our hypothesis is that metacognitive structures like the ones described in Section 5 are crucial. This hypothesis needs to be validated.

A longitudinal study is expensive, and requires a long wait for results to become available. An alternative would be to use a validated instrument like the CPA to identify those at lower levels with executive potential. These individuals can be compared to those who do not test out at as high a potential, to identify the skills that appear to form a substrate for higher-level skills. These substrate skills can then be targeted for training.

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